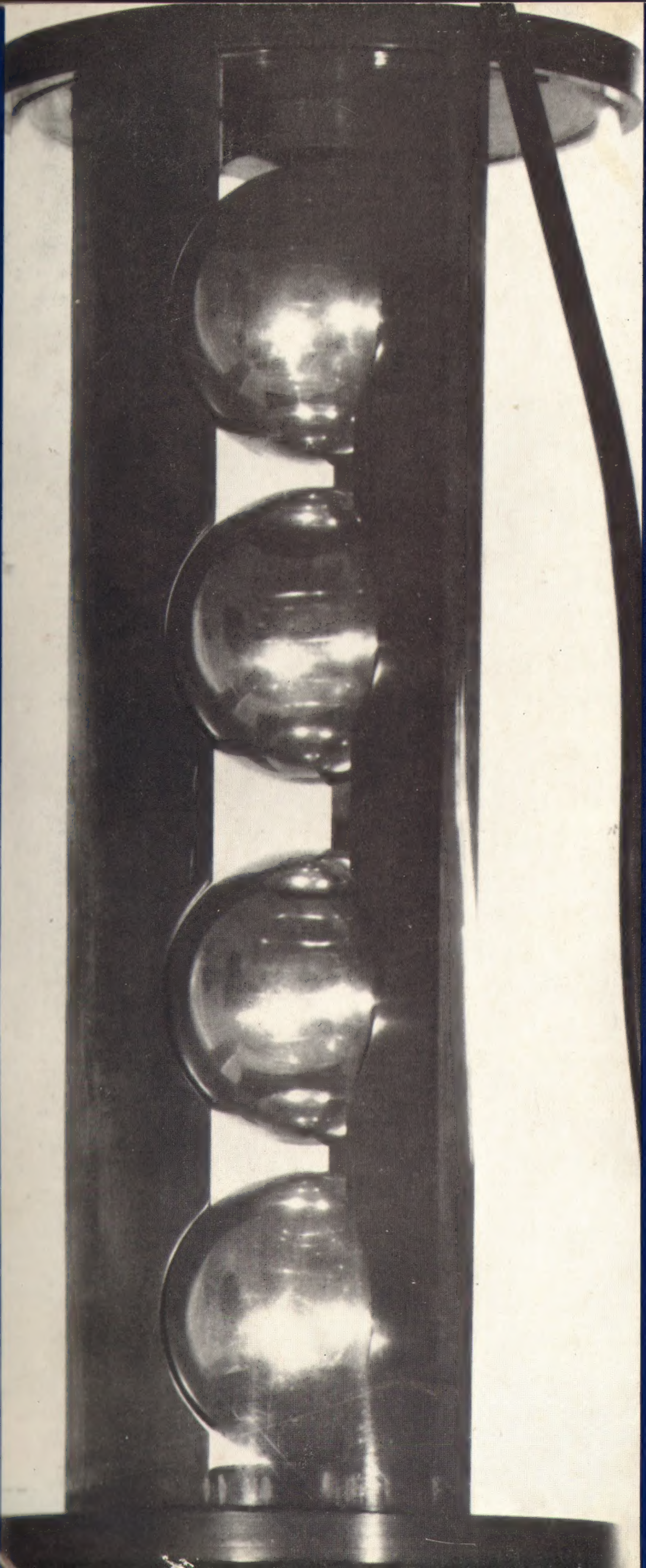
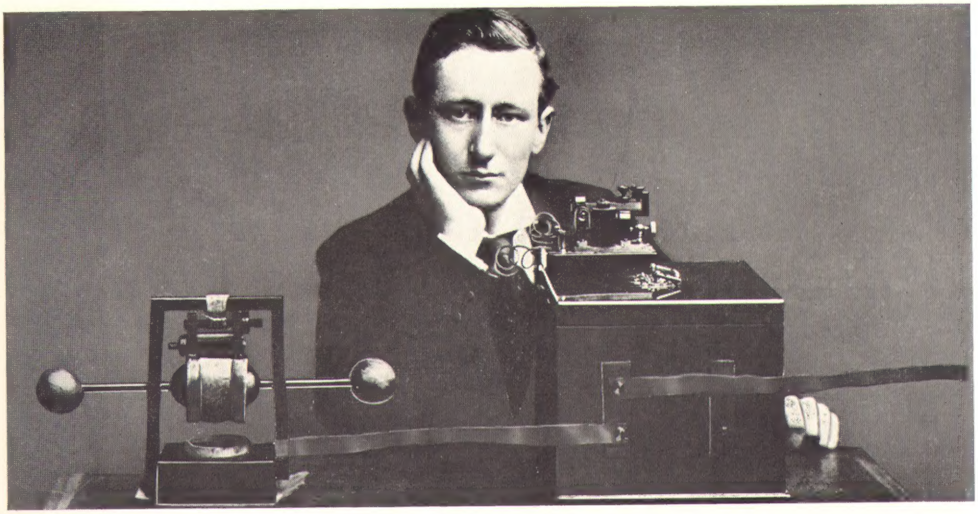


Science Museum

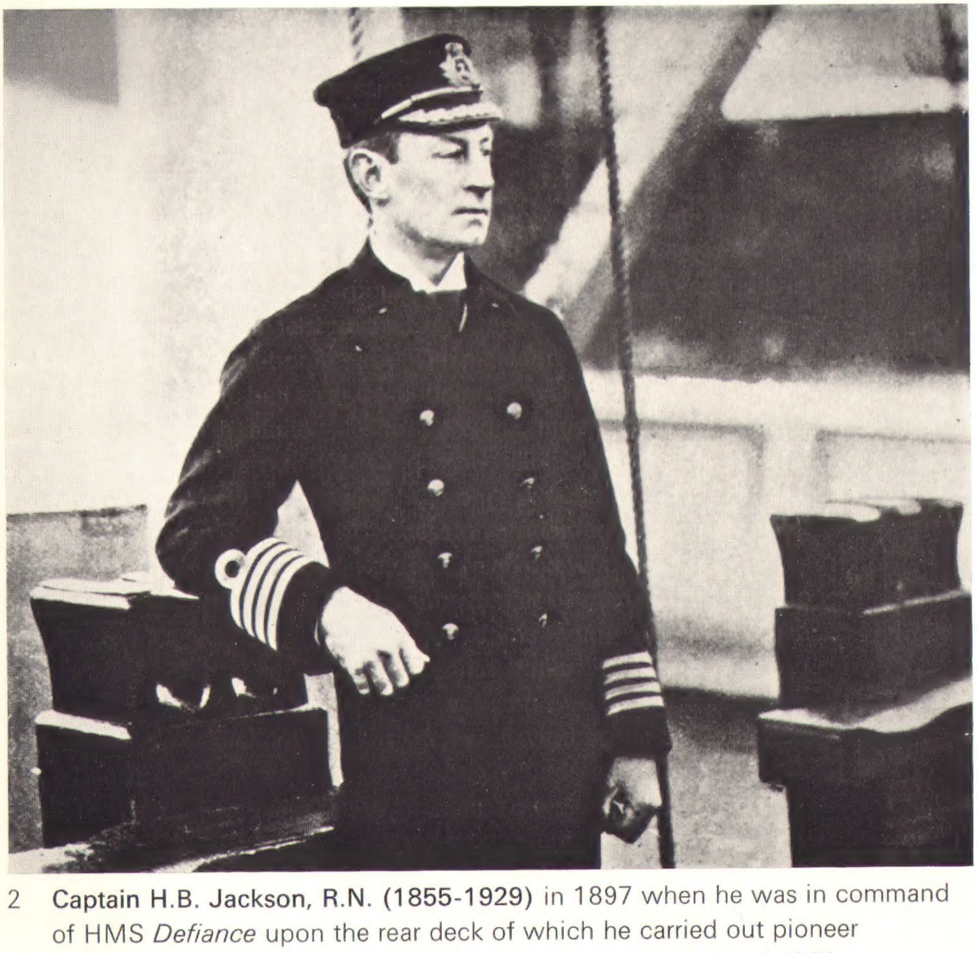
The Origins of Maritime Radio

R F Pocock
G R M Garratt

£6.60



1 **Guglielmo Marconi (1874-1937)** at the age of 22, shortly after his arrival in England early in 1896 with his apparatus for 'telegraphy without wires'.



2 **Captain H.B. Jackson, R.N. (1855-1929)** in 1897 when he was in command of HMS *Defiance* upon the rear deck of which he carried out pioneer experiments in wireless telegraphy during the early months of 1896.

A Science Museum Survey

The Origins of Maritime Radio

The story of the introduction of Wireless Telegraphy in the Royal Navy between 1896 and 1900

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Foreword

Much of the early history of wireless telegraphy from 1896, when Marconi first arrived in England as a young man barely 22 years of age, until 1900 when the use of radio – as we now call it – had become firmly established in the Royal Navy, has hitherto been largely unknown to the outer world. This has been mainly due to the fact that government departments were intimately concerned – particularly the Admiralty and the Royal Navy – and it is not surprising that the details of the story were left buried in the official files.

Fortunately the files were never destroyed. They were recently discovered by Mr R. F. Pocock in the Public Record Office, and their examination by Mr Pocock and Mr G. R. M. Garratt, a Keeper of the Science Museum, has disclosed the fascinating story which is briefly told in the pages which follow.

D.H. Follett
Director
October 1971

The origins of Maritime Radio

Introduction

The history of wireless telegraphy from the time when young Guglielmo Marconi arrived in England early in 1896 until the early years of the new century has hitherto been very largely wrapped in mystery. A few of the salient dates and achievements have been known – for example, the reporting of the Kingstown Regatta in July 1898 and the sending of the first wireless signals across the English Channel in March 1899 – but the inner story of those five or six years has remained almost entirely unknown to modern generations.

The reason for the scarcity of historical data relating to these early years lies almost entirely in the fact that Marconi's principal efforts to promote wireless telegraphy were directed towards the Admiralty and the adoption of his system of signalling by the Royal Navy. Even though the concept of official secrecy may not have been so highly developed in those times as it is today, it was perhaps inevitable that the records of the experiments and demonstrations, the negotiations and the protracted trials should have been buried in confidential files, the story they contained almost entirely forgotten.

Fortunately, the files themselves were never destroyed. Eventually they passed into the custody of the Public Records Office where, in common with a vast collection of national archives, they are available for examination by anyone with the time and enthusiasm for historical research.

But although the files had in fact been preserved, their existence was unknown and it was not until we began to search for material on the work of Sir Henry Jackson at the Public Record Office during 1963 that all the original papers came to light. Their historic value and the importance of the light they shed on the early history of wireless telegraphy was immediately obvious.

The files tell a fascinating story – of the friendship and collaboration which developed between the two so totally different pioneers, Marconi, a very young man of Italian-Irish parentage, not a trained scientist but charged to the brim with enthusiasm, energy and ability and Captain (as he was then) Henry Jackson R.N., a man of mature years, a senior naval officer who, in his capacity as the Officer Commanding the Naval Torpedo School had been carrying out experiments on his own account on the deck of HMS *Defiance* with a view to using Hertzian waves for communication purposes. Though he had not got quite as far as Marconi, they had been working, unknown to each other, on very similar lines when they met in the early autumn of 1896.

Captain Jackson (later Admiral of the Fleet Sir Henry Jackson K.C.V.O., F.R.S.) has always seemed an enigmatic figure to historians in this field. Writers have not been lacking, especially in naval circles, who have attributed priority to Jackson over Marconi, and while this may be partly ascribed to an excess of 'Service loyalty', it has been very difficult to arrive at a proper assessment of Jackson's contribution for the simple reason that the data were not available upon which a proper judgement could be founded.

With the discovery of the original files, however, the whole chain of events falls clearly into place and, for the first time, one can see the true relationship between these two outstanding pioneers in the early history of radio communication. Happily, the assessments which can now be made react to the disparagement of neither; both Marconi and Jackson emerge from the story with their reputations greatly enhanced, Marconi for his vision, enterprise and technical skill, Jackson for his original independent experiments and particularly for the manner in which he accepted, encouraged and assisted the work of his youthful 'competitor'. There was never the slightest hint of patronage or jealousy, such as is so often encountered in lesser men; indeed, his every action testifies to the greatness of his character, a fact which his subsequent career was so amply to confirm.

Apart from telling the story of the collaboration between these two pioneers, the files tell a sad tale of misguided financial stringency and procrastination on the part of the government departments concerned which might easily have had disastrous consequences for the country at a critical time in our history when we possessed scarcely a friend in the world. Such exaggerated parsimony was perhaps a reflection of the lack of scientific and technical understanding which prevailed in those days in the upper echelons of government administration. Today, with our much wider appreciation of the importance of scientific guidance at all levels, it is difficult to imagine that the frustrations which beset Marconi would ever be repeated.

One of the greatest benefits conferred by the invention of radio has probably been the increase in safety at sea which has resulted from the improvement in maritime communications and this was certainly the principal source of satisfaction to Marconi. Until the last decade of the nineteenth century, a ship at sea was an isolated community, entirely cut off from the rest of the world and many ships were lost with all hands, the time and place of their fate remaining unknown for ever. Just how many of these unfortunate vessels perished within reach of assistance, if only they had possessed the means of identifying the other ships at hand and summoning their aid, cannot be estimated but it is perhaps a little ironical that such a humanitarian service as radio telegraphy should have been developed initially by a fighting service and introduced for purely military purposes. However, this was the case. Radio was installed in the ships of the Royal Navy to increase their fighting efficiency and its use was later extended to the merchant service as a result of the Fleet's experience.

The story of the development of radio at sea is, very largely, the early history of radio itself, for it was the fact that Britain was the greatest seafaring nation in the world which led the young Italian, Guglielmo Marconi, to bring his invention to England in the early months of 1896. Perhaps it might be more correct to write, not of Marconi's 'invention', but of his enterprise and vision, his drive and inexhaustible patience, for the fact is that there was very little 'invention', very little original matter in the crude apparatus which the young man, then only twenty years of age, brought with him to England. At his family home near Bologna in northern Italy, he had read of the work of Heinrich Hertz, he may possibly have heard of Oliver Lodge or attended a lecture by his countryman Professor Augusto Righi, but whereas these great scientists had seen their work only as an extension of their knowledge of the physical laws of electro-magnetic radiation and as a research having no practical application, young Marconi saw it as a potentially practicable means of communication – as 'wireless' telegraphy. Throughout 1895 he carried out many experiments in the grounds of his family estate and then, with single minded purpose and the uninhibited enthusiasm of youth, he persuaded his parents to allow him the means to take his ideas to England where, he believed, they would most readily find support and application.

By the time Marconi arrived in England early in March 1896, he had already succeeded in sending and receiving signals over a distance of nearly 1½ miles. Perhaps it is fortunate that he was quite unaware that very similar experiments had been in progress for some months at a Naval establishment, HMS *Defiance*, at Devonport; perhaps it is fortunate that when the two men, Marconi and Jackson, first met in the early autumn of 1896 they were able not only to appreciate the achievements of each other but also to form a friendship which was to make possible a long period of mutual collaboration, a period which was to convey inestimable benefit in the practical development of wireless telegraphy.

The Naval requirement in 1896

With the introduction of fast torpedo boats in the Royal Navy during the 1880's there had arisen an urgent need to discover some means for their accurate identification, especially at night, so that friendly vessels returning to their parent ships could be distinguished from those of an enemy. This need had been emphasized particularly by the findings of the umpires at the conclusion of the 1887 manoeuvres, but no immediate solution seemed at hand and it was not until 1891 that the suggestion of using 'Hertzian' waves was first made by a young torpedo officer, the then Commander Henry Jackson.

The date of Jackson's proposal cannot be fixed with certainty as no contemporary record exists – the earliest evidence being his own recollection nine years later.[1*] In any case, the lack of any suitable apparatus and the demands of his naval duties effectively prevented any practical experimenting for more than four years.

It may seem surprising that a naval officer should conceive the idea of using electro-magnetic waves for such a purpose barely four years after Heinrich Hertz had first demonstrated their existence. It seems unlikely that the subject would have been one to which reference would have been made in the lay press and it is of interest to speculate as to how Jackson may have gained some knowledge of the properties of Hertzian waves. He was not without some acquaintance with electrical matters as he had undergone instruction at the Torpedo School Ship, HMS *Vernon*, in 1881 at the age of twenty-six, and had been elected an Associate of the Society of Telegraph Engineers (later the Institution of Electrical Engineers) two years later.

*See References, Appendix 3

It seems likely, however, that his early introduction to the properties of Hertzian waves may have arisen indirectly as a consequence of his engagement six years later to Florence Burbury, the daughter of Samuel Burbury, F.R.S., a mathematician who published a treatise in 1889,[2] in which he essayed a development of Clerk Maxwell's electromagnetic theory. Samuel Burbury would certainly have been aware of the experimental work carried out so successfully by Hertz and while it can be no more than speculation, it is by no means impossible that Jackson's introduction to Hertzian waves arose in this way.

The essential features of a system of wireless telegraphy were in fact demonstrated at the Royal Institution by Dr Oliver Lodge, then Professor of Physics at Liverpool University, on the 1st June 1894. But Lodge himself saw no practical application for the experiments he demonstrated, nor did he realise their potential value for the purpose of communication. Jackson, who was away on foreign service at the time, missed seeing the reports of Lodge's lecture and so remained in ignorance of the properties of the coherer which Lodge had described.[3]

Thus, when Jackson was appointed to the command of HMS *Defiance* at Devonport in January 1895 he was unaware of the advances which had been made, and although he now had the time and facilities for experimenting he was unable to make a sensitive detector of radio waves to use in his receiver. He was, however, encouraged to persevere by the new interest in technology among his colleagues. The nineteenth century conservatism of the Royal Navy was beginning to break down under the influence of the 1889 Naval Defence Act, and Jackson's endeavours received more sympathy from his superiors than they would have done ten years earlier.

In December 1895, Jackson's attention was drawn to a paper in the *Proceedings of the Royal Society*, describing a series of experiments by Jagadis Bose at Calcutta University. Bose used an equipment based on that shown by Lodge in 1894 with transmitter and receiver in metal boxes mounted on an optical bench, and with this arrangement made extensive studies of optical phenomena at radio wavelengths.[4] The transmitter, which produced waves only 6 mm. long, consisted essentially of two platinum beads on the output terminals of a small induction coil with a platinum sphere of 8 mm. diameter between them. The air-gap alone was relied on for insulation.

Bose's receiver employed a coherer made of two nickel-coated wire springs, interleaved, and with a screw adjustment to control the contact resistance; he believed that this arrangement gave more regular characteristics than were possible with the tube of metal filings that Lodge had described.

Jackson now had enough information to start a systematic series of experiments. Within a few days he had constructed a replica of Bose's apparatus to begin a fresh series of investigations.

Early experiments in HMS *Defiance*

Bose's work was first published in Great Britain on the 12th December 1895. Jackson's experiments, which were later described as starting in December 1895, must therefore have begun in the last two weeks of that month.[5] Naturally, Jackson

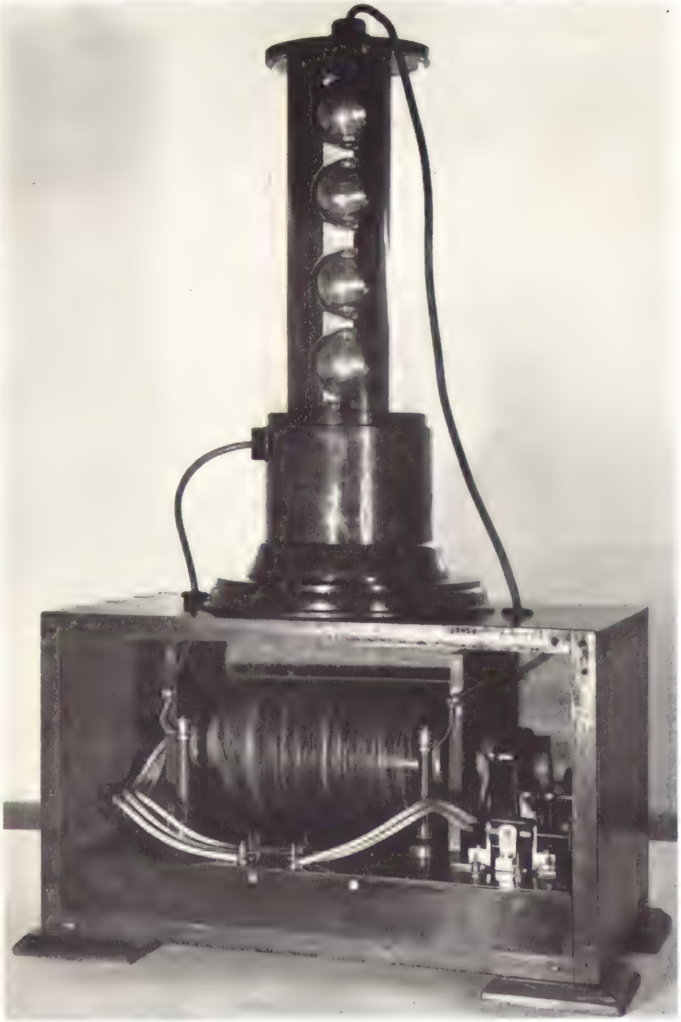
3 **HMS *Defiance* at Devonport in 1897.** Built at Pembroke Dock and launched in 1861, HMS *Defiance* was a 91-gun ship of 5,270 tons. After being laid up for many years, she was re-commissioned at Devonport in 1884 as the Torpedo School.

Capt. Jackson's early experiments in wireless telegraphy were carried out on the deck of *Defiance* during the early months of 1896.

had time to do little more than prove the working of the system in 1895; with the small power available the range of his transmitter was negligible and he made no attempt to transmit intelligence. The earliest description of his apparatus was written in 1899 and is not very detailed, but it mentions that the receiver used a spring coherer and that the transmitter was powered with 'a toy induction coil, giving a 1-inch spark'.[5]

Once he had proved that his system would work, Jackson concentrated on the improvement of its various components, and in the following three months carried out exhaustive experiments to improve the spring coherer. His first idea was to construct a transmitter which was, in effect, a signalling lamp working at long wavelengths (long in the optical sense), and in these initial experiments he used lenses of pitch or glass to focus the radiation at transmitter and receiver; he found that his results were improved by using these lenses.

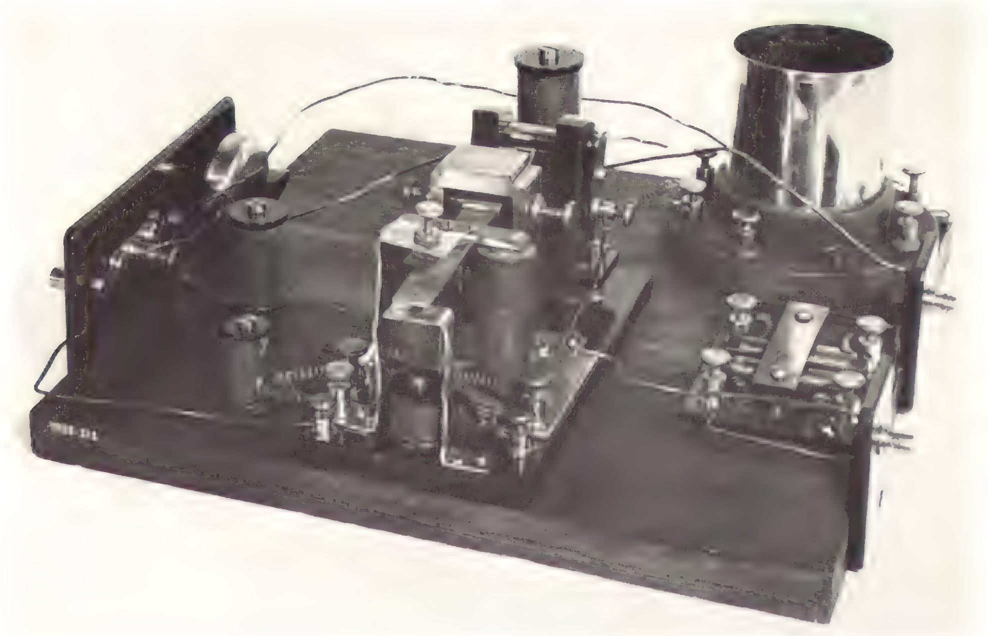
In March 1896 he read Lodge's book based on his lecture of 1894 and used Lodge's discoveries as the starting-point of a new series of experiments, though he was careful to emphasize that Lodge's work contained 'certainly no idea of Morse signals being possible'.[5] He obtained a new induction coil capable of giving a 2-inch spark and used this to power his transmitter, trying different shapes for the spark-gap surfaces and noticing little difference in the performance. He carried



4 **Captain Jackson's Wireless Transmitter of 1897.** The exact history of this transmitter – which is in the possession of HMS *Mercury* at Petersfield – is uncertain. It is believed that this is a fairly accurate reproduction, not an original.

out another, and even more complicated, series of coherer trials with 'metal filings, strips, blocks, springs, carbon and oxides, etc., and combinations of the above',[6] eventually deciding that the metal-filing coherer was the most satisfactory for his purpose. He also discovered the properties of the radio aerial when he attached long wires to his coherers and found that the received signal was stronger as a result, though he had intended these wires to be used solely for ease of handling.[5] However, he did not appreciate the importance of the earth connection until several months later.

Although Jackson discovered the aerial principle at this stage, he did not im-

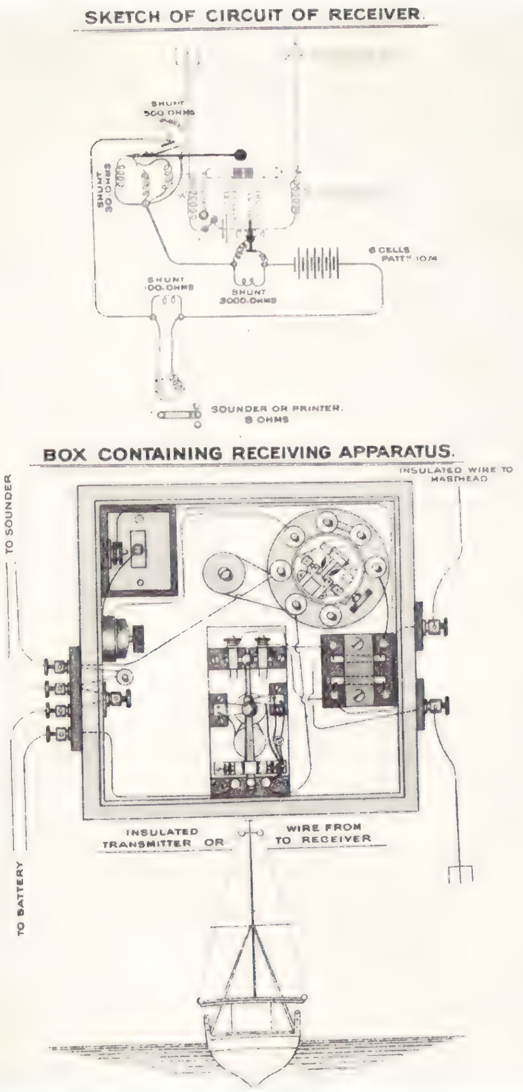


5 **Captain Jackson's Receiver of 1897.** Like the transmitter, this is also in the possession of HMS *Mercury* at Petersfield but it is incomplete, the working parts and the cover of the relay being missing. Its origin is unknown and it may also be a reproduction.

mediately abandon the original form of his apparatus; he was still mentioning the use of pitch lenses in his experiments as late as September 1896.[6]

Jackson's first complete receiver to incorporate all his improvements was built in July 1896. This receiver had an aerial two feet long and a coherer containing a mixture of tin and iron filings in an ebonite tube. The most interesting feature of this receiver was the use of an electric bell as a de-coherer, as was used in the Marconi arrangement patented a month earlier – although one must remember that a provisional patent specification is not published or available for examination and Jackson was, at this time, entirely unaware of Marconi's experiments. On the 20th August 1896, a Morse transmission was successfully recorded on this receiver. The *Defiance* establishment was at that time situated in an old wooden ship-of-the-line in Devonport harbour. This transmission was the first to be made on board ship and, in this rather narrow sense, is the true start of maritime radio. Unfortunately no contemporary report has survived, the date being first stated in 1899 in a report by Jackson's colleague, Captain Hamilton.[7] The account in Jackson's obituary, compiled chiefly from the recollections of his friends, says that the transmission was across the after-cabin of the ship, a range of a few yards only.[8]

However, a series of experiments eight days later gave more encouraging results. This time, fortunately, an official report was made and so more information is available about Jackson's methods and results. The range for most of the trial was



6 Circuit diagram of Captain Jackson's 1897 Receiver. Reproduced from the Annual Report of the Royal Naval Torpedo School for 1897.

25 yards, which was eventually increased to 50 yards in an effort to determine maximum range; presumably this was the maximum free space available in HMS *Defiance*. Jackson also observed that the signal had passed through the wooden bulkheads of the ship with no apparent loss of power.[6]

Jackson and Marconi

Until the late summer of 1896, the development of radio for specifically maritime purposes had been the work of Jackson alone. He was not, however, the only or even the first radio pioneer. Marconi had started his experiments in Italy a year earlier than Jackson[9] and, as has already been mentioned, filed his British patent specification in June 1896.[10] The two inventors met for the first time in the early autumn of 1896. Their professional association soon grew into a close friendship, and it was perhaps partly Jackson's influence which made Marconi's work from 1896 onwards progress in the form of a non-directional system for maritime use rather than as a development of the beamed system for shore-to-lighthouse communication for which the General Post Office was asking.

Their initial introduction took place at a conference held at the War Office on the 31st August 1896 to discuss the military implications of Marconi's inventions. Jackson, now a Captain, attended this conference as the Admiralty's representative.[11] At some time during or shortly after this conference, Marconi gave a demonstration of his apparatus to Jackson at the General Post Office. It was not a very startling performance as the signalling range was only 20 yards with the receiver and the transmitter in adjoining rooms, but it was enough to show Jackson that he and Marconi had been working on very similar lines.[6] In particular, the coherers were almost identical in external dimensions, though the working substances were not the same, Jackson using a mixture of tin and iron filings while Marconi employed filings of nickel and silver amalgam.[12]

In spite of these similarities, the apparatus displayed by Marconi was a more refined and finished equipment than that which Jackson had developed. This was only to be expected; Marconi had started his experiments a year before Jackson and had not had the responsibilities of a naval officer to distract him. However, nothing can detract from the extreme skill and care shown by Marconi, who achieved results far superior to those of any of his contemporaries as the outcome of long and patient investigations. For example, Jackson has recorded that Marconi experimented with five hundred different coherers before deciding which to adopt as his standard design.[6] With such attention to its details, the Marconi coherer was the most efficient detector which had been produced at that time.

Marconi's first major trials in Great Britain were carried out on Salisbury Plain immediately after the War Office conference. Although these trials were officially sponsored by W. H. Preece, engineer-in-chief to the Post Office, Captain Jackson also attended the trials as the Admiralty's observer.

Although the Marconi apparatus, as then existing, was not suitable for installation in warships (it was still a beamed system using parabolic copper reflectors to focus the radio waves at transmitter and receiver), the results obtained in the trials convinced Jackson that it would prove the basis of a practical system. In the course of his report[13] to the Commander-in-Chief, Devonport, on the 16th September 1896, Jackson wrote:

> 'It may be of interest to state that the energy consumed by this apparatus to transmit signals (2 miles) at Salisbury was 13 watts, that for working the masthead

> flashing lamp being about 260 watts . . .'

In its then existing form, Marconi's apparatus was quite unsuitable to meet the severe conditions liable to be experienced at sea,

> 'but', Jackson continued, 'as the principle of its working has been well established with such good results, I consider that a design might well be prepared and made suitable for the roughest usage.'

He set out the broad requirements for such a system in a letter to Marconi[14] which illustrates the direction in which his thoughts were tending, and which is of some historic interest since it constitutes the earliest specification for military radio equipment:

> 'I think personally', he wrote, 'that your apparatus is worth a trial, and would be of use to the service, if the signals can be made over 3 miles, without reflectors: all round lenses would be permissible.
>
> 'The size of the transformer would not be of importance but I would state roughly 4 cubic feet, and a weight of 2 cwt, should not, if possible, be exceeded. The power available would be a continuous pressure of 80 volts, of which 5 horse-power would practically not be much felt and be always available. All parts of the apparatus would have to be protected from wet and capable of standing rough usage, and heavy shocks from the firing of guns.'

The transformer mentioned was intended to replace the induction coil which was used to power the transmitter; in fact, induction coils were retained in the transmitters which were built for the Navy.

The experimenters at Devonport were progressing, but were still not approaching the standard of Marconi's results. During the autumn of 1896 they increased the length of their receiver aerial to 8 feet, and worked at ranges up to 300 yards. This performance was unspectacular in comparison with the range of 2 miles currently being achieved by Marconi, and in all his reports Jackson frankly admitted that Marconi's equipment was superior to his own.

During the winter and early spring of 1897, Jackson redesigned his aerials to take advantage of Marconi's experience and advice. He mounted his transmitter in the gunboat *Scourge*, the tender to *Defiance*, and increased the signalling range to 1,200 yards using aerials 70 feet long.[5]

Jackson's duties kept him busy throughout March 1897. He spent the first two weeks of the month in perfecting the *Scourge* transmitter and then interrupted his radio experiments to travel to Weymouth to attend some torpedo trials. On the morning that he left Devonport, he receved a telegram from Marconi inviting him to a second series of trials on Salisbury Plain.

For these trials, Marconi abandoned the copper reflectors used the previous autumn and used an apparatus very close to Jackson's specifications, with elevated non-directional aerials 120 feet long. Jackson was able to leave Weymouth and visit the trials on Wednesday, the 24th March 1897, and was extremely impressed by Marconi's results. The maximum range at which signals were detected was seven miles, while reliable signals were received consistently at ranges up to four miles in very unfavourable weather conditions. Jackson's report[15] stressed that the principal problem was the elevation of aerials with kites and balloons in squally weather, but pointed out that the fitting of aerials to warships would present no problems as existing masts were ideal for this purpose.

Ship-board Demonstrations at Devonport

In April 1897, Jackson obtained a powerful induction coil capable of giving a 6-inch spark, and used this as the basis of an improved transmitter constructed on lines generally similar to the Marconi set. He used this equipment in a series of trials which appear to have been intended to determine environmental influences on the system and on its signals. Thus, on the 19th May 1897 he tried the set in heavy rain and recorded that he received Morse signals at a range of 1¾ miles.[16]

Jackson now considered that the system was sufficiently advanced to warrant its first official demonstration to an officer of flag rank. Accordingly, a display of the new apparatus was arranged for the Commander-in-Chief, Devonport, on the 20th May.

For the two trials which made up the demonstration, the transmitter was installed in *Scourge* and the receiver in *Defiance*. By this arrangement, with *Defiance* remaining at her moorings, the visitors could observe the effects of signalling over various bearings, at different ranges and from a vessel under way at speeds up to 7 knots.

The first trial was intended to investigate the performance of the apparatus while signalling between ships in a crowded harbour. One word was transmitted every minute, the time and position of *Scourge* in the harbour being noted. The receiver in *Defiance* recorded the signals automatically, an officer attending the apparatus in order to check the time of receipt of each word. There was sufficient sea-room in the harbour to test signals over ranges of up to 5,300 yards.

When this trial was completed, *Scourge* was instructed to proceed up the Lynher river while transmitting a lengthy sentence, the object being to discover the range and accuracy of radio signalling in a harbour clear of shipping. The message (which was the opening sentence of the Court Circular in *The Times* of that morning) was received correctly in *Defiance*, but *Scourge* was unable to steam more than two miles upstream and so the attempt to determine maximum range was abandoned.[17]

Extensive tests with this apparatus continued through the summer, as a result of which Jackson was able to report[18]:

> 'Experiments have shown the impossibility of firing Service fuses or detonators by the induction of the transmitter, that the compasses are unaffected and that shocks are practically unobtainable.'

After the demonstrations of the 20th May, Jackson had expressed the opinion that the performance of his system had reached its limit, and that any improvement would involve the construction of new equipment for which he required financial approval. There is no record of the Admiral's reaction to this report, but we can assume it to have been favourable, for in October 1897, Jackson built a new transmitter using a 10-inch spark coil and an oscillator of four 4-inch diameter aluminium balls. With this transmitter, he sent Morse signals over a range of 6,000 yards and established a signalling link between *Defiance* and the Admiral's House at Plymouth.[19] However, he did not have long to experiment with his new set. On the 1st November 1897 he took up the appointment of Naval Attaché to the British Embassy in Paris, and was succeeded in the command of HMS *Defiance* by Captain F. T. Hamilton.

To summarise his achievements at this time, Captain Jackson had been virtually alone among the senior officers of the Royal Navy in his belief in the value of wireless telegraphy until the summer of 1897. Although the performance of the apparatus which he had designed was inferior to that of the Marconi system, Jackson had more experience than Marconi of the practical problems of operating wireless equipment in warships. He had been experimenting with ship-borne installations since December 1895, while Marconi had carried out most of his trials on land and had not mounted a radio set in a ship until his demonstration to the Italian Navy at Spezia during July 1897.

Jackson's practical knowledge of the peculiar problems of maritime radio engineering, acquired over a period of nearly two years, was invaluable to the Royal Navy, no matter who designed the wireless sets which were installed in their ships. It is perhaps unfortunate that he was forced to abandon his experiments just at the time that they began to show promise of spectacular success, but the truth is that wireless telegraphy was not then so important as to outweigh the need for an experienced torpedo officer in Paris to report on the submarines then being constructed for the French Navy. Among Jackson's other achievements, we must not forget that he left trained staff on HMS *Defiance* who were able to continue his experiments.

Marconi's trials in the Isle of Wight

Once the decision to proceed with the development of wireless telegraphy had been made, the responsibility for its introduction into the Royal Navy passed from the Torpedo Schools to the Signal Committee of the Admiralty, 'an estimable body' to quote Admiral Sir Reginald Bacon, 'who knew the colour of every flag and all about the Morse code, but to whom electricity was a sealed science'. Admiral Bacon was rather unfair in his criticism. There had certainly been no reason for the Signal Committee to have any knowledge of electricity in the past, and the technical improvement of radio systems was still left to the Torpedo Schools. There was, however, a real need for a body to study the tactical uses and implications of the new signalling system, and this subject was perhaps not so far removed from flags and Morse code as Admiral Bacon suggests.[20] At all events, the first act of the

Committee showed a complete appreciation of their responsibilities.

The formation of the Wireless Telegraph and Signal Company* in July 1897 and the acquisition by the Company of Marconi's patent rights in exchange for a controlling interest necessarily led to a severance of the close and personal relations which Marconi had hitherto enjoyed with the General Post Office. He continued his investigation at a new station which he set up at the Needles Hotel, Alum Bay in the Isle of Wight. (A granite column commemorating the radio experiments originally stood at the site of the transmitter on the edge of the cliff, but it has now been moved, presumably because of the risk of cliff falls, to an undignified and inappropriate setting near the forecourt of the Needles Hotel). The Secretary of the Signal Committee, Commander Evan-Thomas, visited Marconi at the Alum Bay station on Saturday the 7th May 1898 but, being himself inexperienced in electrical matters, he took along Lieutenant Hornby of the Torpedo School, HMS *Vernon*, as a technical adviser. He was also accompanied by the Commander-in-Chief, Portsmouth, the formidable and influential Admiral Lord Charles Beresford.

Marconi was able to show them his apparatus exchanging signals with a similar station at Bournemouth, 14½ miles away, using aerials 120 feet high. This performance was a tremendous improvement over his results of the previous year, and was due partly to the detailed improvement of the various components of his apparatus and partly to the introduction of a coupling transformer between the transmitter and its aerial. This device was an essential feature of the experimental tuned apparatus being developed at Alum Bay, but although these tuning experiments are mentioned in the written reports of the naval officers, the aerial transformer (nicknamed the 'jigger' by Marconi and Jackson) is not shown in the circuit diagrams accompanying their reports, probably because the device was not patented till the following month.[21]

Commander Evan-Thomas reported[22] favourably on the standards of working to the Signal Committee but he drew attention, for the first time, to the risks and possibilities of radio jamming:

> 'With the apparatus in its present stage, it seems possible, given instruments of the same, or nearly the same tune, for an enemy to spoil your communications by simply transmitting perpetual signs, these would be shown on all receivers in distance and convert all communications into a jumble. For instance, if a blockaded port has a transmitter, the communications of the blockaders (when you had once got their tune) could always be thrown out if in distance.
>
> 'Again, cruisers watching a channel to which this system might be particularly useful, would find their communications thrown out when most needed, by the presence of hostile ships also using the system.
>
> 'These examples, however, would show rather a reason for having the system in the service than not, if only for the purpose of incommoding our possible enemies.'

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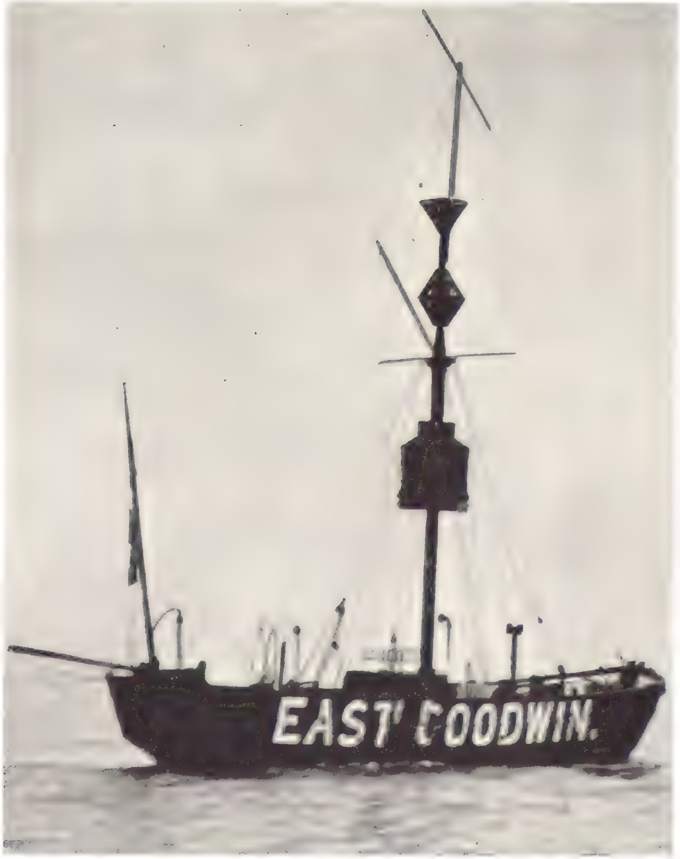
*The name of the Company was changed to *Marconi's Wireless Telegraph Company* in February 1900.

7 **HM Yacht *Osborne*.** Wireless equipment was installed on the royal yacht by Marconi during August 1898 to enable the Prince of Wales (later King Edward VII) to communicate with his mother, Queen Victoria, at Osborne House. More than 150 separate messages were passed over this link during the sixteen days the Prince spent on the yacht while convalescing after an accident to his knee.

Marconi was now concentrating on the maritime possibilities of his system. Among the minor commercial contracts he secured in the summer of 1898, was one for the installation of wireless sets in HM Yacht *Osborne* and in Ladywood Cottage, in the grounds of Osborne House, Isle of Wight, so that the Queen could keep in touch with her son Edward, the Prince of Wales, who was spending a period of convalescence on the royal yacht.

This radio link was the first to be installed in a ship for routine communications and it remained in operation through the month of August 1898. In this month 150 messages passed between the two sets. On the 12th August, *Osborne*, while herself lying off Newtown Bay, established communication simultaneously with Ladywood Cottage and with Alum Bay, thus linking the east and west coasts of the island.[23]

In general, the *Osborne* sets made little technical contribution to the progress of wireless telegraphy. They did, however, demonstrate the reliability of wireless apparatus in regular routine usage on a seagoing vessel, while the mere fact of royal patronage perhaps did as much as any scientific achievement to establish Marconi as a public figure in Great Britain.



8 **The East Goodwin Lightship 1898**. The first lightvessel to be equipped with wireless. She was fitted with a Marconi installation in December 1898 and within only three weeks had occasion to use it to call for assistance to a ship in distress.

The needs of the Royal Navy

This is a convenient point at which to digress from the main narrative in order to discuss the requirements of the Royal Navy and the extent to which the wireless systems then existing could meet these requirements.

The original concept of radio as a means of signalling between torpedo boats and their parent vessels had been modified almost as soon as a practical system became available. The obvious advantages of wireless telegraphy were that it was unaffected by fog or darkness, that its use did not automatically betray the position of the transmitter to a possible enemy, that it enabled an Admiral to send the same signal simultaneously to all units of his fleet at any bearing and at all reasonable ranges and that a single ship could broadcast a distress signal which would be received by any vessel in range which possessed a receiver.

Against these advantages, there were two very real objections to the use of radio in warships – the lack of secrecy and the lack, at that time, of a selectively tuned system. The use of elevated but non-directional aerials, which was one of the important developments of 1897, could prove a distinct drawback in that any signal transmitted would be received by every ship in range, friend or enemy. This disadvantage could be met by the use of sufficiently elaborate codes for all secret messages but no such simple solution was available to the problems posed by the use of untuned transmitters and receivers.

It is perhaps not now appreciated that no tuned circuitry was available during the first five years that radio telegraphy existed. The unfortunate operators of untuned receivers were compelled to decipher their messages from the full spectrum of atmospheric interference, while any unwanted transmitter within range would reduce all signals to chaos as soon as it was switched on. This interference could be, and was, kept to a minimum in naval ships by the maintenance of strict wireless discipline so that one transmitter only was operating at any one time. Such discipline could not be imposed on merchant vessels, or on enemy ships in time of war, so this was obviously only a temporary solution. If the Signal Committee had not known that Marconi was developing a tuned apparatus, the introduction of wireless into the Service might well have been delayed for many years. As will be shown later, the United States Navy did not have this information, and in consequence, did not adopt the Marconi system.

One factor was not considered at the time, though it now seems of great importance. A ship, before the invention of wireless telegraphy, was isolated from the rest of the world as soon as it was out of sight of land. The ranges of wireless systems in 1898 were not enough to alter this state of affairs, and although ranges had increased sufficiently by the end of 1899 to justify the issue of a ship's newspaper on one historic voyage, the Signal Committee in 1898 could scarcely be expected to foresee the future developments.

Decision in favour of the Marconi system

The *Defiance* experiments at Devonport had continued throughout 1898 under the leadership of Captain Hamilton.

While Marconi had concentrated on improving the performance of his apparatus, Hamilton was more concerned with the study of the behaviour of his sets under sea-going conditions. He particularly tried out the apparatus left by Jackson in damp and foggy weather and, as a result, introduced a new aerial with a non-absorbent insulating cover and a new induction coil with improved insulation.

The electrical circuits of the receiver were simplified by eliminating the electrical tapper and substituting a mechanical de-coherer in its place. The necessary mechanical power was already available in the clockwork motor of the Morse printer used to record the signals. Some of the officers in the trials had feared that continuous de-coherence would render Morse signals unintelligible, but the method was quite satisfactory in practice. The entire receiver was now housed in a metal box, which prevented moisture from reaching the circuit and also screened the receiver from the induction of the transmitter.[24]

A further modification of some interest was made by the staff of HMS *Defiance* and was referred to subsequently by Captain Hamilton who wrote[25] that on the 7th January 1899:

> '. . . experiments were started with Sullivan's galvanometer, connected simply to a coherer with a single cell, the mechanical tapper being used, and signals being read by watching the motions of the coil. These were read easily up to two miles without using the reflecting part of the galvanometer, and the experiments promise well.'

By the autumn of 1898, the Signal Committee had a possible choice of five radio systems for further trials – Marconi's, Jackson's and the Lodge-Muirhead systems in Great Britain, and the Slaby and Braun systems in Germany. Only two of these, Marconi's and Jackson's, were really well-tried in practice, and these involved fewer political complications than the German apparatus. Jackson was already serving in the Navy, but his system did not compare with Marconi's either for performance or for reliability. It was a foregone conclusion that Marconi's system would be chosen, and Jackson showed no signs of any jealousy or disappointment at this decision.

Despite the earlier reassurance given by Jackson, the Signal Committee still expressed fears for the safety of the magazines of ships fitted with radio apparatus (it was this fear which had provoked Admiral Bacon's sarcasm regarding their qualifications), and certain prominent scientists were asked for their opinions. Lord Kelvin[26] agreed with Jackson's conclusions:

> 'I believe,' he wrote, 'there would be absolutely no danger from the use of this system on board a ship of war of any class. The risk of accident by the explosion of detonators or of ammunition of any kind for guns or torpedoes will not, in my opinion, be increased in the slightest degree by the introduction and use of Marconi's apparatus for wireless telegraphy.'

W.H. Preece, when consulted by Captain Hamilton, gave a similar opinion.[27]

These two experts appear to have satisfied the Admiralty and the question of safety was not raised again in any official document concerning radio telegraphy.

By the New Year of 1899, all technical objections to the use of the Marconi system in warships had been answered. Only a few months later, Marconi was enabled to demonstrate his equipment in circumstances which, from every point of view, must have surely been ideal; moreover, the measure of success achieved must cause the demonstration to rank as his most spectacular achievement since the inception of his work towards a practical system of wireless telegraphy. Before describing the sequence of events during the Naval Manœuvres of July and August 1899, however, it is necessary briefly to take the narrative back a few months to provide a coherent account of Marconi's experiments during that period.

Cross-Channel radio transmissions

By the end of January 1898, Marconi had established reliable communication over the 14½ miles of sea between his station at the Needles Hotel on the Isle of Wight and another which he had set up on the mainland at Madeira House, Bournemouth. This encouraged him to attempt the longer and far more spectacular feat of transmitting across the English Channel and he wrote to Jackson about the project, doubtless hoping to secure British diplomatic influence in persuading the French Government to agree to the experiment. Unfortunately Jackson was not in Paris at the time and the letter only reached him after considerable delay while he was on temporary duty at the British Embassy in Berlin. His reply[28] was not encouraging:

> 'I am sorry I am not in France so as to answer your question, and help you with getting permission to try your experiments at Cherbourg. Personally, I think you will have some difficulty, unless you transport yourself and instruments to France and carry on the experiments there solely, unless the two Governmental Post Offices took it up.
>
> 'But why not try from the Isle of Wight to Portland Bill where you would have a free sea space of about 45 miles, and would have no difficulty in getting permission: though I daresay it would not sound as much as signalling across the Channel, it would, however, show the possibility of the Channel scheme.'

The French Government, when approached, were quite willing for Marconi to establish a station in France but indicated that they would prefer it to be in the Calais area rather than at Cherbourg. However, as there was, at that time, no station near Dover to receive the transmission, and as the distance from Calais to Alum Bay was far greater than any that had previously been attempted, the cross-Channel scheme was shelved during the summer of 1898. The Portland Bill project was not attempted, perhaps because Marconi appreciated that its publicity value did not approach that of a transmission across the Channel.

In September 1898. the instruments at the Bournemouth station were transferred to the Haven Hotel, Poole. The report[29] of the chairman of the Wireless Telegraph and Signal Company, describing the move, contains an echo of Jackson's advice:

> 'Within the last few days we have had to move our station at Bournemouth four miles farther west, where we have put up the same instruments, the same pole, and everything at the Haven Hotel, Poole, which is eighteen miles from Alum Bay. This increase of distance has no detrimental effect on our work; in fact it seems rather easier, if anything, to receive signals at the Haven Hotel than at our former station . . .
>
> 'We now intend to put up a station between Calais and Dover. There is not the least doubt of success being achieved, because we are doing a parallel distance today without the slightest difficulty. The sea between Calais and Dover is the same sea as between the Isle of Wight and Poole, so the things being equal in both cases we may expect the same success between Calais and Dover as between the other points.'

The cross-Channel system was therefore proved to be practicable by October 1898, and two months later the vital Dover station was established. Marconi was invited by the Trinity House authorities to set up a wireless link between the South Foreland lighthouse and one of the three lightships guarding the Goodwin Sands. The East Goodwin ship was selected, making a total transmission distance of 10·4 nautical miles. A standard set of the period was installed in the ship on Christmas Eve, and was kept in fairly continuous use from the day of its installation. The crew of the lightship and her master, Captain Clayton, learned in two days how to operate the apparatus, and by January 1899 were in complete charge of the equipment, the Marconi assistant 'not being as good a sailor as the instruments have proved to be'.[23]

The South Foreland lighthouse now formed one end of the proposed cross-Channel link, and the Wireless Telegraph and Signal Company re-opened negotiations with the French Government for a station on the French coast. The necessary permission was received on the 2nd March 1899, and was first announced by Marconi while he was delivering a paper to the Institution of Electrical Engineers on the same evening.[23]

On Monday the 20th March, two of Marconi's assistants took the necessary apparatus from London to establish the French station at the Chalet d'Artois, Wimereux, near Boulogne. At 5.00 p.m. on the 27th March the first radio transmission was sent from France to the South Foreland station, over a distance of 32 miles (27·8 n. miles).[30]

The success of the cross-Channel transmission caught the public imagination as no previous radio demonstration had done. A month earlier, the magazine *Punch* had published a cartoon predicting the demise of land lines and submarine cables as soon as wireless telegraphy was perfected,[31] and for a few weeks it appeared that this prophecy would be fulfilled as submarine cable share values fell heavily on the Stock Exchange. After this initial panic, however, a reaction set in and the communications industry came to realise that the 'new' wireless telegraph was to find its chief use as a complement to, and not as a replacement for, the more conventional systems.

Negotiations between the Wireless Telegraph and Signal Company and the Royal Navy

The Signal Committee was now anxious to subject the Marconi equipment to extensive trials under active service conditions, but found that the administrative problems raised by their decision were less amenable to immediate solution than were the technical problems that they had faced previously. These problems arose from factors outside the Royal Navy itself, and a brief discussion of their origins is necessary at this point.

From July 1896 until the formation of the Wireless Telegraph and Signal Company in July 1897, Marconi had worked either on the Post Office premises in London or with the active assistance of Post Office engineers on Salisbury Plain, and, although he received no direct financial help, he had developed a close association with the Post Office staff during this year. This close association necessarily ended with the formation of the Company and its acquisition of his patent; all contact between Marconi and his former colleagues in the Post Office was thereafter on a much more formal basis. At the same time, there were grievances on both sides which such formal contact could not resolve – the substance of these grievances is not relevant to the present paper – and the negotiations between the Post Office and the Wireless Telegraph and Signal Company over the price to be paid by the Government for the use of Marconi's patent started in an unfortunate atmosphere.

These negotiations were no nearer agreement in the autumn of 1898 when the Admiralty proposed the purchase of Marconi apparatus for service trials. In fact, the continued existence of the dispute caused a second dispute to start in the Admiralty itself, for the financial branches were unwilling to apply for Treasury sanction for the purchase of Marconi sets until the Post Office and the Company had agreed on the purchase price. While it was quite understandable that the Admiralty's financial officers would not wish to reach an agreement with a Company which was still negotiating with another Government department, the operational staffs were, equally understandably, very impatient at the prospect of an indefinite delay before the wireless sets were available for trials.

Faced with this situation, the Admiralty attempted to force the Wireless Telegraph and Signal Company to bring the negotiations to a conclusion on the Treasury's terms by questioning the validity of the Marconi patent and in January 1899 Captain Hamilton was ordered, with the assistance of Captain Jackson, to investigate whether the early *Defiance* experiments would serve to invalidate the Marconi patent.

Hamilton's conclusion was that all Jackson's vital discoveries had been anticipated by Marconi, the impression that Jackson had been experimenting before Marconi being due to the latter's reticence in the matter of his patents and the resulting belief among naval officers that these patents were filed considerably later than the true date. Jackson concurred[25] with this opinion.

'In my opinion', he wrote, 'Mr. Marconi's provisional specification, No. 12,039, dated 2nd June 1896, covers all the points worked out in HMS *Defiance* up to the date of my giving up command of that ship on 1st November 1897.'

Hamilton's report[32] was completed by the end of January 1899. Besides its general support for Marconi's patent claims, it also recommended early trials to determine the value of Marconi's system under actual service conditions.

> 'I would strongly urge that the system is capable of great use to HM Navy, principally for fog signalling and for communicating with scouts, as, if it comes up to anything like the promise of the experiments, it would immensely lengthen the distance to which a line of scouts could be thrown out at night or in thick weather.'

The Admiralty agreed with Hamilton's conclusions and accordingly opened negotiations with the Wireless Telegraph and Signal Company for the purchase of apparatus to equip two ships of the Fleet. Marconi's company readily agreed to the sale, subject to the payment of an annual royalty for the use of Marconi's patents. At the end of March 1899, the Company wrote:[33]

> 'The amount of this royalty . . . I shall inform you of when our board has decided what it ought to be, but, in the meantime, we are quite prepared to submit to any tests which you may wish to have the systems and instruments put to . . .'

Exclusive of royalty, the price quoted for the equipment was:

	£	s	d
Complete receiver in box	13	16	0
Inkwriter	15	0	0
Bell		3	6
	28	19	6
Induction coil attachments and transmitting key	4	5	6
	33	5	0

In a further letter,[34] the Company quoted for the induction coil and batteries:

One 10-inch induction coil	£38	11	6
100 M size Obach cells	22	0	0

The question of the royalty to be charged by the Company was discussed at a Board Meeting on the 17th April 1899 and it was decided that this should be at the rate of £100 per ship per annum.[35] By modern standards, this charge seems extremely small but by the standards of the 1890's it was high and certainly considerably higher than any sum which the Admiralty had anticipated paying. It implied a total payment of about £10,000 per annum if every ship in the Fleet were to be equipped with Marconi's apparatus but although such a figure may have seemed large to the Admiralty, it is of interest to note that the General Post Office had contemplated paying a single award of this amount in 1897 in order to secure the exclusive rights in Marconi's patents.[36]

At the Admiralty, the Director of Naval Ordnance, in a minute attached to the letter from the Wireless Telegraph and Signal Company, expressed the opinion that the proposed royalty charge was very high, and asked for a legal opinion as to whether the Marconi system was exempt from the Government's telegraph monopoly.[37] The Admiralty's solicitor was consulted on this latter point, and gave the opinion that the monopoly applied only within the United Kingdom and did not, therefore, cover the use of wireless telegraphy at sea. The question of royalty payment was then referred to the Post Office, but, at the time, no advice could be offered to the Admiralty as the Post Office was waiting for Treasury permission to open negotiations with Marconi's company. The Admiralty was thus unable to come to any conclusion about royalties, and accordingly deferred its reply to Marconi's proposal until the results of the Post Office negotiations were known.[38]

The operational staffs at the Admiralty continued with their plans despite the financial difficulties. The Royal Navy still proposed to equip two ships with wireless apparatus, and it was arranged that these two ships would serve in the manœuvres of the Fleet that summer (1899). Captain Jackson's tour of duty at the British Embassy in Paris was coming to an end, and so he was the obvious choice to supervise the wireless trials. A minute dated 26th June 1899,[39] from the office of the Director of Naval Ordnance contained the suggestion:

> 'That as it is understood that Captain H.B. Jackson is to be in command of a ship during the forthcoming manœuvres, that this apparatus be tried in the ship under his command.'

Appropriate orders were sent to Jackson on the 1st July:

> 'I am to request that you will place yourself in communication with the Company and arrange with them as to the date when the apparatus should be forwarded, and where it should be delivered'.[40]

At the same time the financial problems were temporarily shelved by the action of the Wireless Telegraph and Signal Company, who offered to lend the necessary apparatus to the Admiralty for the duration of the manœuvres and to leave the question of payment until later. The only charge that would be made for this service would be the cost of carriage for the sets and the expenses of the Company's technicians who would install and maintain the equipment.[41]

A collision in the English Channel

While the cross-Channel transmissions were occupying the public attention and the naval community were preparing for stringent tests of Marconi's apparatus under service conditions, an unexpected and striking demonstration of the value of radio at sea occurred.

In the early morning of Friday, 28th April 1899, there was a dense fog in the English Channel which persisted after daybreak. At about 8.30 a.m., the East Goodwin lightship sighted the steamer *R.F.Matthews*, outward bound from the Thames, bearing down upon her. The alarm was given with just enough time to swing the lightship on the strong tide and so avoid the direct collision which threatened, but the steamer struck the lightship a glancing blow and severely damaged her bows on both sides of the stem. Captain Clayton called up the South Foreland lighthouse as soon as the steamer had got clear and on receiving their acknowledgement he transmitted the first radio emergency signal:[42]

> 'We have just been run into by the steamer *R.F.Matthews* of London. Steamship is standing by us. Our bows very badly damaged.'

The Marconi operator at the South Foreland lighthouse immediately telephoned the Trinity House authorities at Ramsgate and alerted the lifeboats at Deal, Kingsdown and Ramsgate. Fortunately the sea was calm and their assistance was not required and, after receiving assurance from Captain Clayton that help was on its way, the *R. F. Matthews*, though herself damaged, was able to continue on her course down Channel.

A replacement for the damaged vessel was towed from Beachy Head by the Trinity House s.s. *Warden* which then towed away the damaged lightship for repairs. Fortunately none of the lightship's crew of seven had been injured in the collision.[42]

9 **HMS *Alexandra*.** The flagship of 'B' Fleet under the command of Vice-Admiral Sir Compton Domville during the Summer Manœuvres of 1899, equipped with wireless. A signal was received on HMS *Alexandra* early in the evening of 31 July 1899 from HMS *Europa*, relayed by HMS *Juno* over a distance of 95 miles reporting that the 'convoy' was being safely escorted. Never before in naval history had a signal been transmitted over so great a distance.

The Naval Manœuvres of 1899

The main object of the Summer Manœuvres of 1899 was to determine the best methods of employing a large body of cruisers in conjunction with a fleet of battleships, and to ascertain the value of torpedo boats and destroyers in such formations. In the minds of the little band of wireless enthusiasts among the more senior officers, however, there can have been but little doubt that the principal value of the exercises would be to demonstrate the importance of wireless telegraphy in a modern fleet. They certainly spared no effort to ensure that the demonstration would be a success and it was arranged that Marconi himself, still only a young man of twenty-five, should observe the manœuvres from Jackson's ship.

The warships immediately available were divided into two fleets: 'A' Fleet, under the command of Admiral Sir Harry Rawson, had 8 battleships and 19 cruisers and was to be located at Belfast at the commencement of the manœuvres, while 'B' Fleet,

10 HMS *Juno*. This was the cruiser equipped with wireless and commanded by Captain H. B. Jackson during the Summer Manoeuvres of 1899, the results of which were to lead to the widespread installation of wireless telegraphy in ships of the Royal Navy.

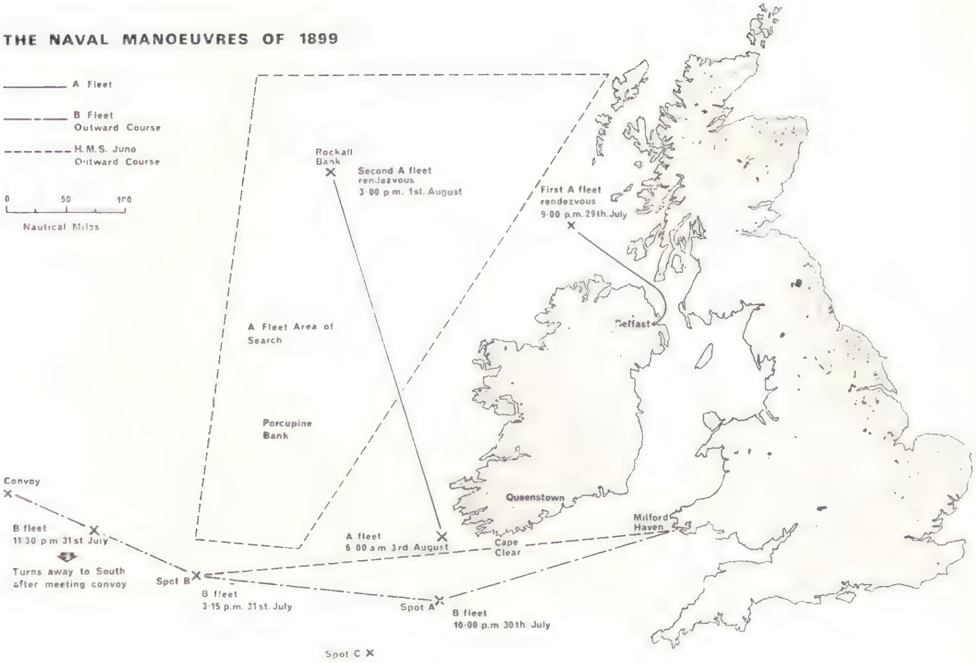
under Vice-Admiral Sir Compton Domville, had 10 battleships and 20 cruisers and was to be at Milford Haven. It will be seen that 'B' Fleet had slightly the stronger force, while 'A' Fleet had the faster ships, since the battleships comprising its main strength were all of the latest *Majestic* Class. This arrangement was deliberately designed to reveal the relative importance of speed and of fighting strength in warship design. 'B' Fleet alone possessed wireless apparatus, the sets being installed in Domville's flagship, HMS *Alexandra*, and in the cruiser commanded by Captain Jackson, HMS *Juno*.

The exercise set for the operations assumed that a convoy of merchant vessels, represented by HMS *Calliope* and HMS *Curaçoa*, was sailing from Nova Scotia to Milford Haven with a single cruiser as escort and was waiting at a rendezvous which was known only to the Admiral commanding 'B' Fleet, whose object was to reach the convoy with a force superior to any that the 'enemy', represented by 'A' Fleet, could assemble before locating the convoy and then to escort it safely to Milford Haven.

11 HMS *Europa*. The third ship of 'B' Fleet to be equipped with wireless. She was a fast cruiser which was sent ahead to make contact with the 'convoy' and, having done so, she sent the signal (via HMS *Juno*) to inform the flagship that the convoy was being safely escorted.

The combined fleets assembled initially in the Channel early in July, 'A' Fleet being at Portland and 'B' Fleet at Torbay. Marconi installed his apparatus temporarily in HMS *Alexandra* and in HMS *Juno* on the 12th July, and extensive tests were carried out with the two ships on the following day in order to determine the best aerial configuration before deciding on a permanent arrangement. *Juno*, with slightly lower aerials than *Alexandra*, could operate over ranges of 13 miles only, compared with 18 miles for the latter ship. It was decided therefore to adopt the system in *Alexandra* for both ships. The permanent installations, with the apparatus in the after signal-house and with aerials 158 feet high were completed on the morning of the 14th July and trials at sea that afternoon proved completely satisfactory, signals being exchanged reliably with the ships 28 miles apart and intermittently up to 29½ miles. On the 15th July two signal ratings from Portsmouth joined *Juno* for instruction in the use of the apparatus. After two days' training they proved thoroughly competent and shared in watch-keeping duties with the Marconi technicians.[43] There followed a strenuous training programme on the ships for fourteen days,

> '. . . transmitting and receiving signals, day or night, at an average rate of 10 words per minute, from distances varying from 28 miles to 200 yards, in fine weather, rain,


THE NAVAL MANOEUVRES OF 1899
A Fleet
B Fleet Outward Course
H.M.S. Juno Outward Course
0
50
100
Nautical Miles
Rockall Bank
Second A fleet rendezvous 3·00 p.m. 1st. August
First A fleet rendezvous 9·00 p.m. 29th. July
Belfast
A Fleet Area of Search
Porcupine Bank
Convoy
B fleet 11·30 p.m 31st July
Turns away to South after meeting convoy
Spot B
B fleet 3·15 p.m. 31st. July
A fleet 6·00 a.m 3rd August
Queenstown
Cape Clear
Milford Haven
Spot A
B fleet 10·00 p.m 30th July
Spot C

12 Map to show the scheme of the Naval Manœuvres of 1899.

fog, thunder and lightning, calms and strong breezes, with the ship stationary, stopped, at high speed and with moderate motion in a seaway.'

With the apparatus installed and working satisfactorily, 'B' Fleet sailed for Milford Haven where an important addition was made to the communications by Marconi, who had brought a third wireless set to Milford Haven for installation in the cruiser HMS *Europa*. This additional set not only increased the operational range of the cruisers of 'B' Fleet by permitting the relaying of messages between ships but, in addition, it provided experience for the first time of the difficulties involved in operating two non-selective systems simultaneously.[44]

Despite the lack of time and the impossibility of carrying out extensive installation trials, the apparatus was fitted in HMS *Europa* without difficulty, thanks to the experience gained at Torbay, and, in practice, HMS *Europa* proved able to transmit and receive over slightly longer ranges than the other two ships. This was due mainly to the elevation of her aerial, 178 feet, as opposed to 158 feet in HMS *Juno* and HMS *Alexandra.* The jiggers' of all three sets were carefully tuned* to the same wavelength, this operation and the adjustment of the receiver relays being carried out by Marconi himself.

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*Some confusion may arise from the use of the word 'tuning' in two different senses in early radio documents. It often implied merely the adjustment of a transmitter or receiver for optimum performance in a sense rather similar to that implied when we speak of the 'tuning' of a motor car engine. But, as in modern radio terminology, it could also imply the adjustment of circuit constants so as to ensure that both transmitter and receiver were operating on the same frequency. During the nineteenth century, this was called 'syntonic tuning' but in this text the more modern term 'selective tuning' is used.

The transmitters in all three sets comprised 10-inch induction coils, the spark-gaps consisting of a pair of 1½″ diameter brass balls spaced ¾″ apart. The receivers were all of Marconi's current pattern employing coherers, tappers and relays, with Morse inkers to record the signals on tape. Power for the transmitters was provided by Obach dry cells. The aerials were made from seven strands of tinned copper wire and suspended from spars lashed to the main topmasts of the ships, being led into the signal cabins via insulators on the starboard side of the quarterdecks.[45]

The official time for the start of the manœuvres was 10 a.m. on Saturday the 29th July. The plans of 'A' Fleet as explained during the previous evening to the newspaper correspondents present at Belfast by Flag-Captain Egerton (Admiral Rawson, having just learned of the death of his brother, felt unable to undertake this duty), were based on the assumption that the convoy would be waiting either at Porcupine Bank or at Rockall, and the search area was planned accordingly. The search was arranged to start at the northern end of the area and spread southwards, but one flotilla of torpedo boats was despatched to sail south through the Irish Sea and make the 'B' Fleet scouts believe that the bulk of 'A' Fleet was also steaming in that direction. At 9.00 a.m. the Fleet left Belfast flanked by torpedo craft, but these light vessels were unable to maintain their speed in heavy seas, and had to abandon their stations and return to harbour as soon as the open sea was reached. By 9.00 p.m., the main units of 'A' Fleet had reached their stations north of Lough Swilly, and had separated to begin the search for the convoy.

Vice-Admiral Domville had the easier task as he was, of course, aware of the place appointed for the rendezvous – 51°40′ N, 19° W – which was considerably to the south-west of Rawson's area of search. (Two well-known naval writers, Sir John Thursfield and Frank T. Bullen, who accompanied 'A' Fleet, had suggested the true place of rendezvous at Egerton's press conference, but their opinion was not shared by Rawson and Egerton.) Domville delayed the sailing of his fleet until 5.00 a.m. on Sunday the 30th July. His strategy was simple but efficient: he appointed two localities, designated Spot A and Spot B, to define the course of his fleet, and a third Spot C so defined that a straight course from the rendezvous to Spot C would pass through Spot B. Thus his scouting cruisers, on reaching the rendezvous, would be assured of meeting the fleet by escorting the convoy toward Spot C.

The bulk of Domville's cruisers, including *Europa*, sailed toward the convoy at 17 knots, while the battle fleet, in line ahead, followed at 11½ knots, the course to Spot A being chosen to keep out of sight of the Irish coast. Meanwhile, a scouting force under *Juno* steered a parallel course 20 miles nearer the coast and looked out for 'A' Fleet, which, thanks to the torpedo boat decoys, was believed to be in southern Irish waters. The fleet reached Spot B at 3.15 p.m. on the Monday, being then 176 miles from the convoy. Domville, anxious to secure the convoy as soon as possible, ordered his slowest battleship, HMS *Thunderer,* to leave the line of battle, and increased the speed of his remaining ships to 12 knots. At 3.30 p.m. his main cruiser force reached the convoy and, while the convoy sailed under escort toward the fleet at slow speed, HMS *Europa* sailed ahead as fast as possible to establish contact with *Juno*. The news that the convoy was approaching was received in *Juno* at about 6.00 p.m., *Europa* being 60 miles from her at that time, but *Juno* was unable to contact *Alexandra*.

Both cruisers continued to steam towards the fleet, and, at 7.30 p.m. *Alexandra* received the long-awaited signal:

> '*Juno* to Flag – Communicated with *Europa* about 60 miles off convoy rendezvous. She was there with convoy, and has now returned to squadron. Convoy following at about nine knots. No enemy sighted by her or by us.'

This signal was relayed to the flagship over a total range of 95 miles. Contemporary newspaper reports describe the excitement in *Alexandra* on its receipt, excitement because it confirmed that 'B' Fleet had achieved its object, and excitement because no signal in naval history had ever before been transmitted over a comparable distance. At 8.10 p.m., a second signal was received from *Juno*:

> '*Europa* alone. *Vindictive* follows two hours later. Afterwards remainder of division with convoy. Keeping touch with you until I know communication is made to Admiral.'

The battle fleet met the convoy and its escorting cruisers at 11.30 p.m., and Domville promptly altered course 16 points to the south in order to increase his distance from 'A' Fleet's scouts before returning to Milford Haven.

'A' Fleet searched unsuccessfully for the convoy throughout the night of the 29th-30th July and, in fog, for the whole of the following day. At 1.00 a.m. on Monday, the 31st July, the battleships gathered at Porcupine Bank, and the cruiser HMS *Minerva* was despatched to Lough Swilly to collect news. The search continued in fog and heavy rain all day, the battleships once more assembling during the night, this time at Rockall. At 3.00 p.m. the next day, they were joined by *Minerva*, with the news that the Queenstown (Cobh) torpedo boats had sighted 'B' Fleet putting to sea and steering south on the Sunday morning. It was evident that the convoy was far to the south of 'A' Fleet's search, and that 'B' Fleet must already be escorting it back to Milford Haven. Rawson decided to order his fleet to return to Belfast via the south of Ireland, hoping to intercept the convoy off the Bristol Channel. Despite a severe shortage of cruisers, which had been scattered in the fog, he accordingly sailed south and was off Cape Clear at 6.00 a.m. on the 3rd August.

Domville, in command of 'B' Fleet had also made his preparations for an action. On the Tuesday, two destroyers of his fleet had entered and secured Queenstown harbour. On the same day, four of his cruisers, sent to patrol off Cape Clear, had seized the telegraph station at Berehaven, thus depriving 'A' Fleet of intelligence of ship movements in the Fastnet area. The destroyer flotillas at Holyhead and at Lamlash were alerted to intercept 'A' Fleet on its return through the Irish Sea. The whole area from the south coast of Ireland to the north coast of Cornwall was a huge trap, with the convoy as bait and with Domville's ten battleships as its jaws.

The anticipated action came at 7.40 a.m. on Thursday the 3rd August, when Rawson's scouting cruisers were intercepted by the 'B' Fleet cruisers off Cape Clear. *Arrogant* returned at top speed to Rawson, while *Furious* and *Pactolus* were put out of action by the 'B' Fleet vessels. Rawson increased the speed of the main body of his fleet to 14 knots in an effort to pursue the cruisers, while Domville, on learning of the presence of 'A' Fleet, detached another four cruisers to Holyhead to support the destroyers in the Irish Sea.

This was the situation at 11.00 a.m. on the Thursday, when the convoy entered Milford Haven. Admiral Rawson thereupon conceded defeat and altered the course of his fleet to proceed direct to Portland.[46]

It must be admitted that, in fact, Admiral Rawson had been given an almost impossible task from the outset as he was called upon to search virtually the whole of the Western Approaches with but nineteen cruisers equipped only with visual means of signalling, much of the search having to be carried out in darkness and in fog. But the situation was not an altogether unrealistic one since the relative strengths and problems of the two fleets formed a reasonable assessment of a disposition which could have arisen in the event of naval hostilities at that period in our history. It was, in fact, extremely unlikely that any foreign power at that time could have mustered more than nineteen cruisers to intercept Britain's merchant shipping.

Rawson undoubtedly compounded his chances of failure by his decision to concentrate the area of his search for the convoy between Porcupine Bank and Rockall but it must be admitted that he was at a major disadvantage from the outset in the absence of any wireless communication between the ships of 'A' Fleet. In the early stages, the news that Domville was steering south from Milford Haven had reached Queenstown early in the morning of Sunday, the 30th July, and was telegraphed almost immediately to Lough Swilly, but it took nearly *fifty-five hours* for the message to reach Rawson and by this time the convoy had been secured by 'B' Fleet and was already more than half-way to Milford Haven. If 'A' Fleet had possessed only three cruisers equipped with wireless, Rawson would have learned of Domville's movements by noon on the 30th July and he could have concentrated his fleet off Fastnet by 3.0 a.m. on the 1st August, in ample time to intercept the convoy and its escorts.

'B' Fleet had used its wireless to good effect but wireless was not, in the final outcome of the manœuvres, a deciding factor; nor indeed, was the absence of wireless communication between the ships of 'A' Fleet. Nevertheless, the whole course of events throughout the manœuvres was such as to emphasize the tremendous importance of wireless communication between naval forces and it was to give very strong support to those advocating the general introduction of wireless throughout the Royal Navy.

The signalling range of 60 miles between *Juno* and *Europa* when the convoy was sighted, was the greatest which had been achieved up to that time by wireless. Marconi believed that this performance was principally due to the use of the 'jigger' and he ascertained that a range of only seven miles was possible when the aerial transformers were removed from the sets.[47] Jackson's official report to Sir Compton

Domville also attributed an increase in signalling speed and an improvement in safety to these devices. He proposed the installation of wireless apparatus in the flagships and the scouting cruisers of the Channel and the Mediterranean Squadrons, in the Commander-in-Chief's offices of the home ports and of Malta in the torpedo school ships at home and in HMS *Vulcan*, the torpedo depot ship in the Mediterranean, and he suggested that two trained signalmen should be established to operate each installation. He recommended the founding of schools of instruction in *Vulcan* and in the torpedo schools, and the awarding of a small pay rise to seamen who completed the wireless operators' course successfully. A suggested syllabus for such a course, drawn up by Marconi, was attached to these recommendations.[45]

These proposals, coming from such a known advocate of wireless as Jackson, might well have received less attention than they deserved. However, they were strongly endorsed by Sir Compton Domville and, in a covering note[48] which was forwarded to the Admiralty with the report, he wrote:

> 'I entirely concur with the whole of Captain Jackson's remarks, and, speaking from my own experience of its use during the last month, I consider, from the Admiral's point of view, that this system of wireless telegraphy is absolutely invaluable. It can be trusted, especially at night or in a fog, when no other system is perfectly reliable.
>
> 'I would submit that the proposal to fit certain ships with it be carried into effect as soon as possible.'

The recommendations of Jackson's report met with a favourable response at the Admiralty. Rear-Admiral Archibald Douglas, then Second Sea Lord, proposed that, in anticipation of the general adoption of wireless telegraphy, a further eight sets should be purchased immediately from the Wireless Telegraph and Signal Company and used for familiarization training of the men of the Channel and Mediterranean Squadrons. While this proposal met with general approval, the Director of Naval Ordnance stressed the fact that the Post Office had not yet told the Admiralty of the results of their negotiations for the right to use the Marconi patents. Rear-Admiral A.K. Wilson, at that time Third Sea Lord, and therefore Controller of the Navy with responsibility for the design and equipment of ships entering the service, however, held that the sensational results of the recent manœuvres showed that the adoption of wireless telegraphy was essential for the fighting efficiency of the Navy, and that therefore the Admiralty should start equipping the necessary warships without waiting for the decision of the Post Office.[49]

The First Lord, the Right Hon. G.J. Goschen, concurred with the views of those who urged the immediate adoption of the Marconi system, but expressed the opinion that the £100 royalty for each installation asked for by the Wireless Telegraph and Signal Company was excessive, and should not be considered as binding the Admiralty to that royalty for any future agreements. He added an important note[50] to his minute:

> 'Let the historical and scientific parts of these reports be printed confidentially

omitting administrative proposals and unnecessary details. They are of such great and permanent interest.'

We may be grateful that the foresight of the First Lord resulted in the preservation of the most important documents of the period and left us such a complete account of the origins of radio at sea.

A brief note appended to the above minutes stated that the sum of £1,550 had been saved on the Navy Estimates for that year and would be available for the purchase of wireless apparatus.

The Wireless Telegraph and Signal Company in Commercial difficulties

During the first eight months of 1899, the performance of the Marconi system had been demonstrated on three separate and highly contrasted occasions – the cross-Channel transmissions, the collision off the Goodwin Sands, and the Naval manœuvres. There seemed to be no obstacle in the way of the ultimate financial success of Marconi and of the Wireless Telegraph and Signal Company, but by the end of the year the situation had changed greatly.

The scientific world found itself divided into two camps over the question of the commercial utilisation of wireless telegraphy. Marconi's supporters claimed that he had been the first man to construct a practical apparatus to make use of Hertzian waves and was therefore entitled to profit financially by his invention. Their opponents claimed that, as the equipment of Marconi and other radio pioneers was based on known scientific principles and derived from existing scientific apparatus (notably that of Sir Oliver Lodge), no one person had any claim to a monopoly of the use of Hertzian waves. The more extreme arguments of this group were summed up in an article[51] in *Nature* on the 27th April 1899:

> 'The fact is that we have in these repeated sensational experiments a pure scientific apparatus boomed by energetic financial speculators for their own individual gain, and not for the benefit of the public – the worst feature of this money-grubbing age'.

In a scientific age, such controversy is almost an inevitable part of progress, its results generally beneficial and, by itself, it could not have harmed Marconi. The allegations and heated comment, however, were seized upon and developed by Marconi's rivals to query the validity of his patents, and the controversy concerning the identity of the 'inventor' of radio has not completely died down to this day. However, there was little evidence of the growing threat to Marconi's financial position when he sailed for New York on the 11th September 1899 on what appeared, at least superficially, to be almost a social occasion.

Marconi's visit to America in the autumn of 1899 was occasioned by the tremendous interest which was being taken on both sides of the Atlantic in the yacht races for the America Cup in which Sir Thomas Lipton's yacht *Shamrock* was challenging the American *Columbia.* Marconi had been commissioned to install wireless apparatus in one of the steamers which would follow the yachts, in order to report the progress of the races to the newspapers while the boats were out of sight of land. He received a considerable welcome in New York from the press reporters and photographers, and for the next few weeks his time was fully occupied in superintending the operation of the wireless apparatus, which performed faultlessly and by means of which many thousands of words of press reports were forwarded which could not, in the circumstances, have been transmitted by any other form of communication.

When the races were completed – and Lipton's yacht *Shamrock* had been as unsuccessful as every other British challenger for the cup – Marconi remained in the United States in order to demonstrate his system to the Navy Department. Two warships, the battleship USS *Massachusetts* and the cruiser USS *New York,* were made available for the trials, and as the two ships remained in contact when they were thirty-six miles apart, Marconi may well have felt satisfied with the performance of his apparatus. But the US Navy insisted on two further conditions – that the signals should remain intelligible when the transmitter was screened by the tall buildings near the Hudson River, and that the signals should remain intelligible when a shore station was transmitting at the same time as one of the warships – and the equipment failed to meet these requirements. It was useless for Marconi to assure the Navy Department that his tuning system would satisfy the second requirement and go some way towards meeting the first requirement; without a demonstration or a technical description any verbal assurance was valueless. Marconi, for his part, was not prepared to reveal the details of his tuning system until the necessary patent had been granted. The US Navy, lacking the advance information which Marconi had made available to the British Fleet, shelved any decision to use his equipment until more satisfactory results were available.

Marconi returned to England, without any American contracts, to find that another disappointment awaited him.

Four Marconi sets had been supplied to the Royal Engineers on the outbreak of war in South Africa on the 10th October 1899, and the Company confidently anticipated further orders from the Army in Natal. But the Army sets failed to perform as well as expected, and, instead of prompting further orders, the four sets were never even taken to the front line. The failure to secure a lucrative Army contract was all the more bitter when the Wireless Telegraph and Signal Company engineers investigated the faults and found that the failure of the sets was not due to any defect in their construction but to the sappers themselves, who had failed to provide any adequate masts for supporting the aerials.[47]

Thus at the conclusion of 1899, the Wireless Telegraph and Signal Company had still not negotiated any substantial contract. Those who had invested in Marconi stock in 1897 had not yet received a dividend on their capital and, now that the negotiations with the Post Office had broken down, the only hope of financial success was to obtain a contract with the Royal Navy.

Suspension of negotiations between the Admiralty and Marconi's Company

The difficulties which had prevented any direct financial agreement between the Admiralty and the Company at the beginning of 1899 still existed at the end of the year. On the 4th September 1899, the Admiralty had written to ask the Post Office of the state of their negotiations, and had received the unsatisfactory reply:[52]

> '... the Company have made a proposal, but it is of such a nature that the Postmaster-General does not think that Her Majesty's Government could possibly entertain it. The whole matter is, however, under . . . consideration, and it is possible that after further negotiations the Company may be disposed to modify their terms.'

Unlike Marconi's other potential customers, the Royal Navy did not need to be convinced of the value of wireless telegraphy. As we have already seen, the operational staff had estimated an immediate requirement of eight sets, and the Admiralty attempted to keep wireless training going during the negotiations by offering to buy these sets outright. This solution did not appeal to the Wireless Telegraph and Signal Company, who preferred to adhere to the policy they had adopted earlier in the year, of selling the sets for a sum which represented little more than the bare production cost, and earning a profit for the company by charging a royalty of £100 per ship per annum for the use of the Marconi patents. Reasonable though such a proposition may now seem, the terms appeared outrageous to the financial branches of the Admiralty and, at one stage, the Director of Naval Contracts minuted :[53]

> 'The terms proposed by the Company are preposterous, and they refuse to sell instruments exclusive of royalty, leaving the amount of royalty to be settled afterwards.'

One can perhaps scarcely blame the Company for refusing to sell the sets until the royalty question had been determined since, by prolonging the negotiations indefinitely, it would clearly have been possible for the Admiralty to reduce the value of any royalty to a negligible amount. Nevertheless, the Company was naturally anxious to promote the use of its apparatus in the ships of the Royal Navy and they therefore offered to lend the eight further sets required by the operational staff upon the same terms as had been agreed in the case of the Summer Manœuvres. Once again, however, this eminently practical solution was rejected by the financial department of the Admiralty on the grounds that it would be improper for the Admiralty to conclude an agreement with the Company at a time when differences were still outstanding on a very similar matter between the Company and another government department, the General Post Office.

To a degree, the Company was in a strong position in that the operational requirements of the Fleet necessitated the installation of eight sets as quickly as possible and there was, at that time, no alternative supplier. The Admiralty, however, still possessed one weapon in the financial battle ; there was a legal method of obtaining the use of a patented invention which was needed urgently for the national defence, even if the patentee objected to its use. This was the power retained for the Crown in the Patents, Designs and Trade Marks Act of 1883 which enabled the Government department concerned to manufacture and employ the invention on terms settled by the Treasury after hearing all the interested parties.

The Admiralty therefore decided to commence the manufacture of wireless transmitters and receivers on its own account, obtaining those components which could not be made at HMS *Vernon* from sub-contractors. Jackson had already been appointed to *Vernon,* on the 20th October 1899,[54] in order to instruct the officers who would be supervising the training courses in wireless telegraphy, and the Admiralty ordered him to report on the apparatus which would be required to manufacture eight sets of wireless equipment. Jackson himself clearly regretted the whole chain of circumstances which had resulted in his appointment to a job which he regarded as disloyal to his friend, Marconi, and his report to the Admiralty stressed the importance to the Service of a speedy reconciliation.

Jackson reported that the Wireless Telegraph and Signal Company had informed him that they were now willing to sell the apparatus outright for £1,000 per ship, and while this was a very large sum, it might prove profitable in the long run to accept it. There were several important developments pending in the Marconi system[55] and, by keeping on good terms with the Company, the Royal Navy could ensure that they would be advised of these developments as they were perfected and offered all improvements at a favourable price. In the meantime, the apparatus being manufactured in HMS *Vernon* was not as yet equal to Marconi's in standards of performance, though Jackson was confident that it could be brought up to these standards after a few months. He had designed the sets to resemble the Marconi pattern as closely as possible, so that the operators could make the transition from the *Vernon* sets to the Marconi sets without difficulty, and so that duplication of spare parts could be avoided when Marconi sets were brought into the service. His report[56] concluded:

> 'As I have had much personal intercourse with Mr. Marconi, I should much like that he or the company be informed of the steps the Admiralty intend to take, i.e., if the manufacture will be independent of the company, as in that case I shall feel bound to hold no further correspondence or intercourse with him. I would observe that I have refused one invitation of the company to visit their Chelmsford Station and Works since this matter has been in abeyance.'

On the 7th December 1899, letters were sent to the Wireless Telegraph and Signal Company, the General Post Office and the Treasury advising them of the decision of the Admiralty to manufacture their own wireless apparatus.

The trials of the *Vernon* system

The initial order for sets from HMS *Vernon* was limited to two equipments only, the tappers, coherers and tuners for these instruments being made in *Vernon* under Jackson's supervision, while the remainder of the components were purchased from civilian contractors. The sets were completed and installed in HMS *Hector* and HMS *Jaseur* on the 1st December 1899, the former having an aerial 162 feet high, while the aerial in *Jaseur* was only 100 feet high.

Trials with these two ships began in the Solent on the 2nd December, but ran into trouble immediately. *Jaseur* reported receiving reliable signals at ranges up to 10 miles, but the *Hector's* receiver would not function at more than ¾ mile. The tests were therefore postponed while *Hector's* receiver was examined. The defect was found to be due to a faulty relay; this was corrected and the trials were continued. The first series lasted until the 15th December, and the sets were worked over ranges up to 11½ miles.

With the first trials successfully completed, the equipment in *Jaseur* was transferred to the battleship HMS *Canopus*, and a second series of trials started on the 16th December. *Hector* and *Canopus* made a series of transmissions between St. Catherine's Point, on the Isle of Wight, and Ower's Light, off Selsey Bill. It was reported that *Hector* received signals from *Canopus* at ranges up to 16½ miles, while *Canopus* was unable to receive from *Hector* at greater than 12 miles. Both ships observed that signals disappeared at these ranges when land intervened between transmitter and receiver.

On the 20th December, Captain Jackson left HMS *Vernon* to take command of HMS *Vulcan* in the Mediterranean Fleet.

Trials continued with the original apparatus installed in *Jaseur* once more, and ranges slowly improved until, by the 14th February 1900, *Jaseur* was receiving signals at 20 miles. This was considered to be the practical limit available with the existing apparatus, as results had been found to be inconsistent and unreliable at ranges over 13 miles using 100 foot aerials. The sets were therefore transferred to HMS *Jupiter* and HMS *Hannibal* and later trials concentrated on increased range using improved aerials.

In these later trials, signals were reported to be received consistently at 20 miles and occasionally at 32 miles range. On the conclusion of the trials, HMS *Hannibal* received her anchoring orders at a range of 19 miles in mist, and anchored without sighting the fleet.

With the range available at a satisfactory figure, a final series of tests was made with these two sets to determine the reliability of the apparatus. For this purpose *Jaseur* and the *Hannibal* were used to transmit orders to the salvage teams working on the wreck of the *Belleisle*. The salvage operations lasted for a week, at the end of which it was reported that both sets had functioned satisfactorily without requiring any adjustment.[57]

The *Vernon* system was working reasonably well, but the results on trials did not approach the standard of performance which the Marconi system had achieved under active service conditions. The *Vernon* sets might solve the immediate problem of providing equipment for training wireless operators, but, unless their performance could be improved, they would be inadequate as substitutes for Marconi sets in fighting ships.

The re-opening of negotiations with Marconi

The Admiralty had not lost all contact with the Wireless Telegraph and Signal Company when the decision was taken to manufacture apparatus in HMS *Vernon*.

On the 14th December, 1899, seven days after the Company had been informed of the Admiralty's decision, Major Flood-Page, the managing director of the Wireless Telegraph and Signal Company, called at the Admiralty for an informal discussion with Rear-Admiral Wilson.[58] The principal purpose of his visit was to ensure the continuation of the good relations existing between his Company and the Royal Navy by assuring the Admiralty that the Company did not regard the Admiralty's action as an act of hostility. He also renewed the offer to lend sets and technicians to the Navy until the outstanding dispute over Marconi's patent royalties should be settled.

The Company and the operational staff of the Admiralty both had good reasons for maintaining the friendly relationship which they had achieved. The Company hoped to secure a lucrative contract from the Royal Navy, and the Admiralty in return appreciated the value of maintaining contact with the world's leading manufacturer of wireless apparatus. The Admiralty's financial branches were in a less well-defined position. While they were responsible for securing the money necessary to maintain the Fleet at the maximum standard of fighting efficiency, they also had a more general responsibility to uphold the authority of the Government in a dispute with an outside body. This unhappy division of loyalties had the unsatisfactory effect that problems tended to be shelved rather than solved, in order to avoid the need for making unpopular decisions.

As the trials of the *Vernon* system progressed and showed that these sets would be quite inadequate as substitutes for the Marconi equipment, the operational staff of the Admiralty took the view that, whatever decision other government departments might reach, the Navy could not afford to be without Marconi sets any longer. After much internal discussion, the Admiralty at last decided to accept the offer of the previous December and to borrow Marconi sets to familiarise wireless operators with their working. The acceptance of the offer, on the 25th January 1900, stressed that the Admiralty did not feel any need to employ Marconi technicians and required the wireless sets alone.[59] It was also stated that the Admiralty was not in a position to discuss royalties, and suggested that the Company should negotiate directly with the Treasury.

This did not satisfy the Company, as they preferred that while the sets remained their property they should be in the care of their own employees. They reiterated their original conditions for the offer: that the sets and their technicians should be loaned to the Admiralty. The Admiralty finally accepted this condition and, as a temporary measure, agreed to allow the Marconi operators to accompany their sets at a salary of £3 a week, with board and lodging provided free.

By the end of February 1900, the Admiralty had at last become convinced that, as a long-term solution, they had no alternative but to accept the terms proposed by the Company and on the 15th March a formal application was made to the Treasury in which it was stated that:

> '. . . My Lords, however, feel so strongly as to the absolute necessity of obtaining the free use of this invention for HM Navy that . . . they see no alternative but to accept unconditionally the proposals of the Company.
>
> 'I am therefore to request that the Lords Commissioners of the Treasury will give their sanction to the Lords Commissioners of the Admiralty entering at once into an agreement with the Marconi Company for the use of their system of Wireless Telegraphy by HM Navy on the payment of a Royalty of £100 per annum for each installation . . .'

The Post Office had been informed towards the end of February of the Admiralty's decision to seek Treasury sanction for the payment of the royalty demanded by the Company[60,61] but, pending the receipt of the Treasury's formal approval, it seems to have been thought impractical to give the Marconi Company any hint, even informally, that a change was about to be made in the official policy and that, in all probability, their terms would be accepted. Still in ignorance, therefore, at the end of March of the moves which were taking place within the Admiralty and the Treasury, and which were likely to give them all they asked, the Company may surely be excused the sense of frustration in which they addressed a letter to the Admiralty containing a distinct hint that they were impatient to bring an end to the long drawn-out negotiations. Furthermore, they pointed out:[62]

> '. . . we are a Company existing among other things for commercial purposes and it seems to us most unbusinesslike that no decisions should be arrived at as to the amount which HM Government should pay to this Company for the use of the Marconi system on board the Ships of the Navy.'

Financially the Company was still in a weak position, but a number of small private orders had been received early in 1900 and had doubtless encouraged the directors to take a firm stand with the Admiralty. Looking back from the vantage point of the present day, there is perhaps some lesson to be learned from the fact that the prolonged financial negotiations with the Admiralty had effectively deprived the Fleet of essential wireless communications for a period of more than ten months at a time when it was expected that Britain would become involved, at any moment, in a European war (for the negotiations took place in the months following the Fashoda crisis), and when Britain, already at war with the Transvaal, was virtually without an ally in the world. It is ironic that, at the end of all this negotiation, the Admiralty agreed, unconditionally, to the terms which had been put forward by the Wireless Telegraph and Signal Company in April 1899.

Although Treasury approval was actually given on the 4th April, discussions in regard to details continued within the Admiralty for yet a further five weeks and it was not until the 8th May that the Marconi Company was at last informed, somewhat obliquely, that their demand for a royalty of £100 for each installation would be granted. The information was conveyed to them in the form of an enquiry from the Admiralty as to the sum the Company would charge, per installation, for supplying a total of thirty-two complete sets upon certain conditions, one of which included the payment of the royalty which had been for so long a bone of contention.[63]

The thirty-two sets were to be disposed of as follows:

Channel Squadron	6 sets
Mediterranean Squadron	6 sets
Reserve Squadron	4 sets
Home Ports (including Portland)	4 sets
Torpedo Schools	4 sets
Signal Stations	4 sets
Cruisers on manœuvres	4 sets
Total	32 sets

The Company's quotation was accepted and delivery of the sets commenced at the end of July. The whole order was completed by November, the cost of each installation amounting to £196 . 14 . 4, of which the principal items were two 10-inch induction coils (one being a spare) at £36 . 14 . 3 each and two coherer-type receivers which were quoted at £44 . 8 . 0 for the pair.

Wireless telegraphy on the Cape of Good Hope Station

The thirty-two sets ordered in April 1900 were not the first to be installed in the Navy's first-line ships. There were already four Marconi sets owned by the Government – the four sets discarded by the Royal Engineers in South Africa at the start of the Boer War. After lying idle for several months, they were transferred to the charge of the Senior Naval Officer at Durban. The first to arrive, on the 17th March 1900, was installed in HMS *Thetis*, which thus became the first ship to carry wireless telegraphy apparatus in an active theatre of war. By the 9th April, the three remaining ships of the Durban Squadron, HMS *Forte*, HMS *Magicienne* and HMS *Racoon*, had been fitted with wireless sets and their signalmen had been instructed in the use of the apparatus. Trial transmissions were made over 53 miles between *Thetis* and *Forte* on the 13th April.

All four ships were employed in the blockade to prevent supplies from reaching the Transvaal through the neutral port of Lourenço Marques, and all four reported that the new signalling equipment was invaluable in this service. The principal advantage reported from the blockading vessels was that signals could be sent in good time to prevent the same ship from being searched twice, and thus the warships were able to operate independently over a wide area. They also reported that signals could be sent and received in a ship steaming at full speed, so that signals could be made during the pursuit of a suspected merchantman.

The Senior Naval Officer discovered another, slightly less respectable, use for the apparatus:[57]

> 'It also furnishes a method of eluding the restrictions imposed by neutrals on belligerents, who, by international law, are prohibited from signalling from neutral ports to ships outside them, information relative to the enemy.'

Obviously, this advantage existed only so long as the neutral port authorities did not possess a radio receiver!

The Summer Manœuvres of 1900

When the trials of the apparatus constructed by HMS *Vernon* were completed early in 1900, a further seven of Jackson's sets were ordered, making a total of nine altogether. The first three of this second batch of sets were allocated to the training schools, two being intended for *Vernon* and one for *Defiance*. However, these three sets were diverted at the last minute to the China Squadron to meet the demand for improved communications as a consequence of the Boxer risings.

The wireless sets were despatched from Portsmouth on the 3rd July 1900 in the troopship *Jelunga*. On arrival in the Far East, they were installed in HMS *Barfleur* and in the Taku forts for the duration of the emergency.

The next eight sets produced, i.e., the remainder of the second batch and two of the third batch, were installed in ships of the Channel Squadron, the vessels fitted being the battleships HMS *Majestic* and HMS *Camperdown* and the cruisers HMS *Vindictive,* HMS *Hawke*, HMS *Ariadne,* HMS *Diadem,* HMS *Blake* and HMS *Edgar.* All of these ships were employed in the 1900 Summer Manœuvres, the apparatus from *Camperdown* being transferred to Admiral Noel's flagship HMS *Alexandra* for this exercise.

The manœuvres, which lasted from 24th July to 3rd August, were designed to determine the optimum distance at which a temporary naval base should be located to support a fleet engaged on blockading a hostile port upon which an enemy fleet was assumed to be based.

For the exercise, the ships were divided into two fleets, 'A' Fleet under the command of Admiral Rawson comprising four battleships at Berehaven, four more at Lough Swilly and yet another four initially in the Mediterranean, while 'B' Fleet under the command of Admiral Noel comprised nine battleships at Milford Haven and four at Lamlash in the Firth of Clyde. Each fleet was given the problem, first of assembling and concentrating its forces before defeating its enemy in a fleet action and confining the remaining ships within their harbours. The plan was well conceived but, unfortunately, the failure of communications which resulted from a series of technical defects in the wireless sets in 'B' Fleet robbed the manœuvres of much of their value either as an exercise in naval tactics or as a demonstration of the value of wireless at sea.

The first indication of a fault in the wireless apparatus came in the late evening of 24th July. At 7.40 p.m. Admiral Noel's scouts sighted a squadron of 'enemy' cruisers. Noel brought up his battleships under cover of darkness with navigation lights extinguished and intercepted the cruiser squadron at 3.20 a.m. By 4.00 a.m. he realised that the umpires had not received the signal in which he claimed the destruction of the cruisers and, on investigation, he learned that several ships were reporting reduced working ranges on their wireless equipment. By the afternoon of 25th July, the wireless sets in Noel's fleet were completely out of action but he was nevertheless, able to unite his two battle squadrons on the following day.

Admiral Rawson was rather more fortunate with his communications and his first act was to concentrate his forces. This was accomplished without difficulty, the necessary orders being passed from Rawson's flagship *Majestic* through the cruiser *Blake.* On the afternoon of the 25th July, with Rawson's fleet well into the

Atlantic, his scouting cruisers sighted Noel's battleships concentrating off the south coast of Ireland. The signal, relayed through *Diadem* and *Blake,* reached Rawson by the evening of the 25th July, enabling him to sail south to intercept the enemy fleet.

In all this time, Noel had no information about Rawson's movements, and his strategy was accordingly to cruise through the Irish Sea and off Fastnet in the hope of encountering Rawson in passage from Berehaven to Noel's base at Lamlash. During the night of the 30th July, the passenger steamer *King Orry* bound from Douglas to Kingstown (Dun Laoghaire), was rammed by the battleship *Trafalgar,* the accident fortunately causing little damage to either vessel.

During the 28th and 29th July, the wireless operators in Rawson's fleet reported receiving indecipherable signals, which were assumed at the time to be intermittent snatches of Noel's messages received at freak ranges. In fact, Noel's apparatus was unserviceable at the time, and it is now clear that these ships were experiencing atmospheric interference.

Rawson's fleet took up their stations at the south of the Irish Sea on the morning of the 2nd August. Noel, in the meantime, had learned of Rawson's movements through his scouts on the afternoon of the 31st July, and, concentrating his battle fleet, sailed south to intercept Rawson. Rawson, for his part, was not then prepared for battle; his two slowest battleships had been unable to maintain their stations during heavy weather the previous day, and he could assemble only ten capital ships against Noel's thirteen. He decided that discretion would prove the better part of valour, and used the superior speed of his fleet to escape from Noel. With this indecisive pursuit, the manœuvres came to an end.

The total failure of the wireless apparatus in one fleet was a severe disappointment to the Navy's wireless experts, and the faulty sets were subjected to a complete examination. It was found that the equipment had failed through breakdown of the insulation due to moisture. There was no explanation given for the lack of similar trouble in the other fleet.

This investigation showed that the poor performance of the *Vernon* sets on trials was further reduced by their unreliability under active service conditions, and confirmed the general opinion among the operational staffs of the Navy that a high standard of performance and efficiency could be obtained only from Marconi equipment. Fortunately the orders for this equipment had already been placed by the Admiralty.

There is a general impression among the newspaper reports of the period that the Admiralty decided to order Marconi sets as a result of the poor performance of the *Vernon* sets during the manœuvres, but as has already been shown, the decision had been made at least four months before the manœuvres started. The failure of the sets did, however, result in the start of a major modification programme at HMS *Vernon.*

While the technical performance of the wireless equipment had been a disappointment, the officers of the wireless branch were heartened by the high standard of operating in Rawson's fleet. Some of the credit must go to Commander Scott, his torpedo lieutenant, and also to Commander Nicholson, captain of HMS *Blake.*

Nicholson was normally commanding officer of HMS *Defiance* and he had subjected the *Blake's* equipment to severe tests in *Defiance* before the manœuvres. Under Nicholson's command, the standard of wireless operating in *Blake* was probably the best in the Royal Navy.[64]

The equipping and training of the Fleet

About a month after the manœuvres, the increased establishment of two trained signalmen (Higher Standard) in each warship fitted with wireless apparatus was approved by the Admiralty.[57] Training courses, postponed from the spring, started at Devonport, the course for torpedo warrant officers, torpedo instructors, chief armourers and armourers lasting a full ten days, while that for signalmen (H.S.), who required less Morse practice, took five days only. Two ships at Devonport were allocated for the wireless courses, the *Defiance* and her Tender, the *Confiance,* and two of Jackson's sets from *Vernon* were used for the training programme. (See Training Syllabus in Appendix 1.)

The first seven of the thirty-two Marconi sets ordered for the Navy arrived in September 1900. The delivery of this substantial order caused an expansion of the wireless branch of the Navy in the autumn of 1900, which in turn necessitated an expansion in the wireless training facilities. Accordingly, training was shared between Devonport and Portsmouth, the men of higher rating attending courses at the *Vernon* establishment, while those of lower rating were still instructed at *Defiance.* Officers in general attended the *Vernon* courses. With two wireless schools in existence, the demands on training equipment and personnel were reduced sufficiently to permit the course for signalmen (H.S.) to be increased by two days. Two Marconi sets and two Jackson sets were issued to each school, and the historical old frigate HMS *Warrior*, the first ironclad warship ever built for the Royal Navy, was taken off the Reserve and sent to Portsmouth to serve as a wireless training ship.[65]

Three sets were allocated for training the Mediterranean Fleet, these being installed in Jackson's ship, HMS *Vulcan*, and in HMS *Renown* and HMS *Canopus.* Despite these arrangements, Jackson was still complaining that the equipping of the Navy with radio apparatus was being done 'rather hurriedly, so that we suffer from want of skilled operators'.[66]

The final delivery of Marconi sets was made on the 22nd November 1900, and by the end of the year the Royal Navy possessed a total of thirty-two Marconi and nineteen Jackson sets which were allocated as follows:

Allocation of W/T Sets (as at end of 1900)	*Marconi Sets*	*Jackson Sets*
Channel Squadron	6	2
Mediterranean Squadron	4	3 (+1 spare)
Reserve Squadron	3	3
Training Squadron	4	—
China Squadron	3	3 (+1 spare)
Torpedo Schools		
HMS *Vernon*	2	2 (+1 spare)
HMS *Defiance*	2	2 (+1 spare)
Shore Stations	3	—
,, ,, (awaiting installation)	5	—
Totals	32	19

The situation in other navies

As we have seen, large-scale adoption of wireless telegraphy by the Royal Navy took place throughout 1900 and was well established by the end of that year. The situation was considerably different in most foreign fleets.

The Italian Navy had been the first (after the British) to investigate the Marconi system. During July 1897, Marconi demonstrated his apparatus to the Italian naval authorities at Spezia. The transmitter was set up in an arsenal on shore and the receiver in the ship *San Martino*: signals were received at a range of 16 kilometres (8·65 n. mi.). As a result of this demonstration, the Italian Navy set up shore stations at Spezia, Leghorn, San Bartholemo, and Varugiano. It was the work of an officer, L. Solari, and a signalman, P. Castelli, at one of these stations which produced the iron-mercury-carbon coherer and the receiver circuit used by Marconi in the first transatlantic transmissions in December 1901.[67] A few ships carried wireless equipment in 1900, but the senior officers tended to regard radio with scepticism and had little confidence in the apparatus for serious work.

The French Navy was carrying out extensive trials following the cross-Channel transmissions but had not yet reached a decision on the use of wireless telegraphy.

The Japanese Navy had purchased five Marconi sets. These had been installed in the *Fuji*, the *Yashima*, the *Asama*, the *Akashi* and the *Yaeyana*. They performed well during the 1900 manœuvres and the Navy proposed to install Marconi sets in other first-line ships.[57]

The German Navy was, at that time, a relatively small fleet as the huge expansion of the early twentieth century had not started. The army had sponsored trials of Professor Slaby's system and an efficient apparatus had been evolved which was available to the fleet when required.[68]

The United States Navy had postponed any decision about the use of wireless telegraphy pending the availability of an efficient tuned system.

The situation in the Russian Navy was rather more complex, and is referred to below.

Russian wireless telegraphy experiments, 1895-1904

The Russian physicist, Alexander Popov, often referred to in Eastern Europe as the 'inventor of radio' was a contemporary of Jackson; in fact there is an amazing similarity both in the methods used by these two pioneers and in the dates of their principal achievements.[69]

Popov first performed experiments duplicating the work of Hertz as early as 1889, but he appears to have made little progress until the publication of Lodge's book late in 1894. Using Lodge's work as a guide, he constructed a detector for thunderstorms, which he described in a paper to the Russian Physical Society on the 7th May 1895.[70] From the point of view of the historian of radio telegraphy, the interesting feature of this detector was that it anticipated many of the details of the early radio receiver. In particular, it was the first circuit to be described in a scientific publication in which the resistance changes in the coherer were indicated by the working of an electric bell, and the clapper arm of the bell was used as an automatic decoherer. This arrangement was developed independently by Marconi in the summer of 1895, and again by Jackson in July 1896. All three of these circuits (Marconi's, Jackson's and Popov's) seem to derive from a coherer-relay-bell circuit invented and described by Lodge in 1894.[3]

Popov first thought of using this apparatus for communication purposes in the same month as Jackson, December 1895, for an expanded version of his paper of March 1895 was published in January 1896 and expressed the opinion that his receiver could be used to detect Morse signals provided a more powerful transmitter were available.[71]

There is no evidence to show that a more powerful transmitter was constructed; in fact Dr Süsskind[69] has shown that Popov's principal interest in the early spring of 1896 was the study of X-rays, so that he would have had little time or finance for telegraphic experiments. Nevertheless, there was at least one radio transmission made at Kronstadt in these months, at a lecture by Popov to the Russian Physical Society on 24th March 1896. Here again, no contemporary record has survived and the Society minutes merely refer to a demonstration of Hertz's experiments. The information that a radio signal was, in fact, transmitted and received at this lecture came many years later from the personal recollections of three members present at the meeting, and, according to their statements, the words 'Heinrich Hertz' were received on the apparatus in the lecture room.[72] One account of this demonstration states that this signal was transmitted over 250 metres (275 yards), though this hardly seems consistent with the usual lecture-room demonstration with transmitter and receiver in the same room. One possible explanation is that two separate trials have been confused in the memories of Popov's colleagues, and, the Russian Navy having suppressed all publication of Popov's results for security reasons, there is little chance now of resolving any such confusion.

It has been shown, however, that Popov can have made little genuine progress towards a practical radio system in 1896, for one of his friends has recorded the surprise shown by Popov at the first newspaper account of Marconi's work, which reached Russia in September 1896.[73] Popov immediately realised that Marconi's apparatus was based on the same principles as his own, and, after writing to a local Kronstadt newspaper to establish this point, he resumed his experiments.

The apparatus used at lectures in the previous spring was modified for naval purposes, and, mounted in the cruisers *Russia* and *Africa*, was used in trials in Kronstadt harbour, when the maximum signalling range was recorded as 640 metres (704 yards). The Russian Navy, in particular Admiral S.O. Makaroff, was now taking an interest in the possibilities of radio signalling. Partly as a result of Popov's demonstrations, and partly because of the news reaching Russia of Marconi's successes, the Naval Ministry granted funds for the construction of new apparatus. With this equipment, Popov had increased his working range to 5 kilometres (2·7 n.mi.) by the end of the summer of 1897.[74]

It will be noted that these results were very closely comparable with those achieved by Jackson at the same time. In view of the five-month lead which Popov had established over Jackson in the previous year, the similarity of their results is a commentary on the slight progress made by Popov between March and September of 1896.

During the 1897 trials, it is claimed, Popov observed the reflection of radio waves from other ships in the harbour – an observation which has led some writers to proclaim him as the 'inventor of radar'. While Popov's observation was not without interest, it is certainly one for which little originality can be claimed since every physicist from Hertz onwards was well aware that radio waves were reflected from metallic bodies and Hertz himself had even put the phenomenon to practical use in order to measure the wavelength he was using. Several references make it clear that the phenomenon was familiar to both Marconi and Jackson in the autumn of 1896.[75] Furthermore, the basic principle of radar involves far more than mere reflection; it involves the reception of the reflected signal back on the site of the transmitter and the accurate measurement of the time interval – in millionths of a second – between the transmission of a signal and the receipt of the echo, an achievement which would have been utterly impossible with the apparatus and techniques available at the end of the nineteenth century.

Popov continued his experiments throughout the summer of 1898 and worked at the problem of eliminating the relay from his receiver. This was at much the same time as the staff of HMS *Defiance* were considering the same problem, and both establishments reached a solution within about a month of each other. The Russian receiver, however, used a telephone receiver to give audible signals, while the *Defiance* apparatus had provided visual signals on a galvanometer.

In January 1900 the battleship *Grand-Admiral Apraxin* ran aground on Suursaari Island in the Gulf of Finland. As part of the rescue operations, Popov set up a radio link between the island and the nearest mainland town Kotka, 50 kilometres (27 nautical miles) away. The link remained in operation until April 1900 and, after the salvage of the grounded battleship, it was also used to direct the rescue of a group of fishermen stranded on an ice-floe in the Baltic. The performance of the Suursaari installation was sufficient to persuade the Russian Naval Ministry to decide to install wireless apparatus on its ships, but the only immediate result of this decision was the establishment of a repair shop at Kronstadt under Popov's supervision. Radio links were also set up in the Black Sea between Odessa and Tendra and in the Gulf of Taganrog. In 1901, a squadron sailing from Sevastopol to Novorossiysk reported receiving signals at 112 kilometres (60·5 n. mi.) but even then few ships had radio equipment. It took the outbreak of war with Japan in 1904 to force the Russian Navy to equip all its principal ships with wireless apparatus, and then the demands proved far too great for the small Kronstadt works. The ships were hurriedly fitted with sets bought from the German Slaby-Arco-Braun Company, which, Popov remarked, proved noticeably inferior to those made at Kronstadt.[74] It is difficult to assess how much of this inferiority was due to the comparison of a factory-produced apparatus with a hand-made model, and how much was due to the lack of trained and experienced wireless operators in the Russian Navy. An intelligence report on signals intercepted by HMS *Diana* at Suez shows that the rate of working was extremely slow by British standards, while the Royal Navy interpreters were particularly critical of the poor standard of grammar and spelling among the Russian operators.[76]

Developments in 1901 in the Royal Navy

With more than fifty sets in use, the Royal Navy's wireless experts had a considerable quantity of information about the performance and features of the radio equipment available. The incoming reports were analysed by breaking down the system into nineteen separate features. The Mediterranean Squadron reported that seven of these items were better in the Marconi system, ten in the Jackson system and two were equal in both. Ships on home stations, however, preferred ten of the Marconi features to eight in the Jackson system with one equal in both. From these reports, recommendations were made for improvements in the sets still being constructed at HMS *Vernon.*[77]

From the beginning of 1901, wireless telegraphy instruction was included as a regular part of the syllabus for all officers and ratings attending courses in HMS *Vernon.*

When the results of the 1900 manœuvres had been analysed, more attention was paid to the insulation of the components of the Jackson sets. The apparatus still under construction in *Vernon* was improved in detail, particular attention being paid to the signalling key, the tapper (for de-coherence) and the aerial coupling transformers, until the performance of the sets was equal to that of the Marconi equipment. The final design was approved by Jackson on the 5th February 1901. With the specifications completed, orders were placed for a further fifty-two sets from *Vernon*, while the existing Jackson sets were modified to the new standards.[77]

These sets represent the ultimate development of untuned spark-gap radio systems and they served the needs of the Navy until the introduction of tuned apparatus in the next twelve months rendered the older systems obsolete. The distribution of all the untuned sets in the Royal Navy is shown in Appendix 2.

The principal contributions to the invention and development of radio

This record of the origins of maritime radio has primarily been a narrative of the British achievements in this field. There are three reasons for this bias.

The first reason has been the practical one of the limitations of the available documents. Three pioneers have been credited, by various authorities, with the invention of radio. Marconi is the most important of the three, and is usually acknowledged as the first man to transmit Morse signals by radio waves. However, his trials at Pontecchio are almost entirely undocumented and his biographers are forced to make elaborate estimates of the vital dates of his early experiments. Popov's experiments at Kronstadt have been subjected to minute examination by leading historians supported with the full resources of the Soviet government, in connection with the celebrations for the fiftieth anniversary of 'Radio Day', but the sum total of their efforts has been the discovery of two papers on atmospheric electricity and a handful of recollections by elderly physicists. By way of contrast, the experiments at Devonport from 1895 to 1897 have been recorded in detail by Captain Jackson and Captain Hamilton. Jackson is probably the only radio pioneer who has left a complete account of his sources and experiments leading up to his first successful radio apparatus.

The second reason for the British bias of this paper comes from a consideration of the sources of the mainstream of radio development. In the record of radio research from 1895 to 1898 there are four great names which stand out. The first is the Italian, Marconi, whose most important work was carried out in Great Britain. The other three great pioneers are all British – Lodge, the scientist, whose studies were the inspiration for the initial invention of radio; Preece, the civil servant, himself a distinguished engineer, who shepherded the young Italian inventor through his first difficult months in a foreign country until he had made his own reputation; and Jackson, the one practical radio engineer who could talk to Marconi as an equal and give him genuine advice and encouragement in his experiments. It is questionable whether Marconi, only twenty-two years old, would have succeeded without the help of Preece and Jackson.

The third, and principal, reason is that the history of radio at sea in the nineteenth century is very largely the history of the wireless branch of the British Fleet. From the first experimental ship-board transmissions to the large-scale installation of radio in a fighting fleet, virtually every important development found its first application in the Royal Navy.

The Royal Navy's interest was, in fact, of paramount importance at this time to both the direction and rate of wireless development. If confirmation of this were needed, it would be amply provided by the long letter from the Managing Director of the Wireless Telegraph and Signal Company which appeared in *The Times* on the 18th July 1900. Frustrated over a long period by the procrastination of the Post Office, Major S. Flood-Page was constrained to comment:[78]

> 'If, however, some departments of state are apathetic and others hostile, I am glad to say that the Admiralty is fully alive to the value of the system in its application to ships of war and has arranged with this Company to install Marconi's

> wireless telegraphy on board more than thirty ships and torpedo stations . . .'

The prolonged dispute with the Post Office was doubtless having an adverse effect on the progress of the Company and it is certain that the substantial Naval contract for thirty-two sets, the biggest it had ever received, was an important factor in establishing the finances of the Company upon a firm foundation. The development of wireless telegraphy would unquestionably have been seriously delayed if the Company had been allowed to suffer a financial crisis at this stage of its career.

A large part of the Royal Navy's contribution to the development of radio is directly attributable to the work of Captain Jackson. He has often been portrayed as an unsuccessful rival of Marconi, since the independent radio system produced at Devonport in 1895-1896 was abandoned in favour of Marconi's apparatus. This is altogether too narrow a view of his achievements. His early work shows a depth of vision equalled only by Marconi himself. While Preece was thinking of wireless telegraphy solely as a short-range link to offshore islands, and Lodge, by his own admisssion, could see no practical use at all for radio telegraphy,[79] Jackson was urging the adoption of the system as the only practical method of ship-to-ship signalling under unfavourable weather conditions. As early as September 1896, Jackson was writing :[13]

> ' . . . signals could be as readily, and more quickly made by its means, at all times, than by the present system of Morse signalling, and also in a fog, and when the ships are not visible, or even aware of their proximity to each other. This would be invaluable for friendly torpedo boats to signal their approach ; also signals could, if desired, be printed by a Morse or other printing telegraph . . . for military purposes, as an auxiliary signal for fog, and transmitting secret intelligence, its adoption would be almost invaluable . . .'

From December 1895 to November 1897, the development of radio in the Royal Navy was almost entirely due to Jackson's own efforts. On his appointment to the British Embassy in Paris, he left a staff with sufficient experience and enthusiasm to continue his work. By the end of 1899, he had created a coterie of officers dedicated to the development of wireless telegraphy, which ensured the establishment and maintenance of high standards of wireless working throughout the Fleet. During the difficult period of negotiation with the Treasury and the Wireless Telegraph and Signal Company, Jackson remained unswervingly loyal to his friend and colleague, Marconi, and obstinately unwilling to accept any but the best equipment for the Navy.

Jackson's selfless enthusiasm earned him the respect of his superiors in the Navy and was an important factor in the decision to adopt the Marconi system. In October 1900, the whole question of the validity or otherwise of the Marconi patents was referred to him, and the official policy of the Admiralty was based mainly on the opinion which Jackson then gave to Admiral Fisher.[1] A.W. Chisholm-Batten, then Assistant Director of Torpedoes, summed up the Admiralty's views :[80]

> 'Captain Jackson's remark . . . that "even if the Marconi Company's patents are bad and if they are prepared to supply the Admiralty with instruments on moderate terms, we had better continue to deal with them" appears sound, and is concurred in.'

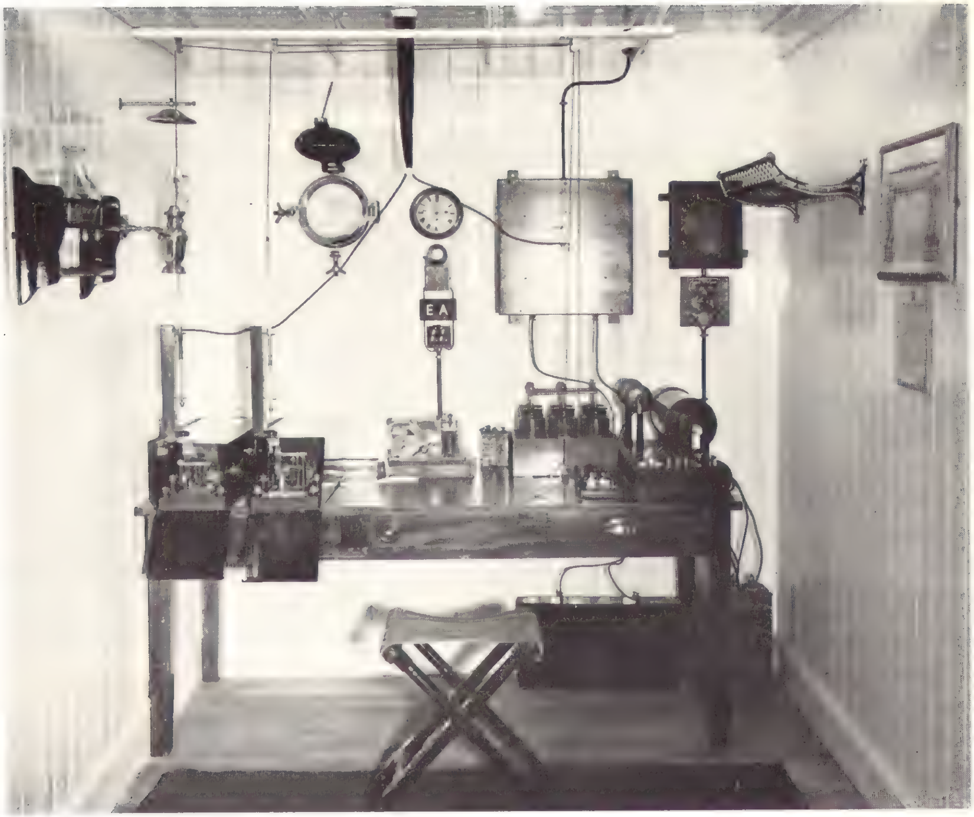
It is difficult to state precisely which radio developments were due to Jackson. There were so many experimenters in this field that it is hard to allocate particular devices to the credit of any one man. Certainly Jackson was responsible for the first simplification of the rather complicated Righi oscillator, by showing in his apparatus of May 1897 that oil insulation of the transmitter spark-gap was unnecessary. He was probably partly responsible for the simplifications resulting from the abandonment of elevated capacity plates at the tops of aerials, though there is little direct evidence of his work in this respect. He was one of the first practical experimenters to dispense with a relay in his receiver, though this improvement was partly due to Captain Hamilton's experiments and was anticipated by the work of the Reverend Frederick Jervis-Smith in 1897.[81]

In 1901, the Royal Navy had ninety-four radio sets in use, of which thirty-one were constructed to Marconi's design and sixty-three to Jackson's. It is little wonder that many seamen regarded Jackson as the true inventor of radio telegraphy. Unfortunately this view became public property when Jackson was appointed to the post of First Sea Lord in 1915 and the few biographies which have since appeared have tended to repeat this tradition. This legend has now been effectively refuted.[82] Regrettably, now that the extreme claims of Jackson's advocates have been discredited, there may be a tendency to belittle the tremendous contributions which he did, in fact, make towards the development of radio. It is the opinion of the present authors that Jackson's achievements were such that it is immaterial whether or not his earliest experiments were anticipated by Marconi. Without Jackson's efforts, radio would not have developed so far as it did by 1900. Though he was not the inventor of radio telegraphy, he was certainly the father of maritime radio.

The revolution in naval technology

During the period of British naval pre-eminence in the closing decades of the nineteenth century, it was an accepted axiom that the Royal Navy should not pioneer any new development of naval technology. This principle, based on the reasonable consideration that Britain had more to lose than other countries in the event of failure, was invoked by the opponents of the Dreadnought scheme as late as 1906.[83] But, in fact, the principle had already been abandoned when Jackson and his supporters guided the Signals branch of the Royal Navy into the twentieth century.

Jackson was regarded as a perfect gentleman and an officer of the highest standards by all who knew him. It was these qualities which made him one of the principal figures in the galaxy of talent associated with Lord Fisher's reforms in the Navy. His integrity led him to put the good of his Service before all other considerations.



13 **A typical ship's wireless cabin of 1900.** Although typical of the 1900 period, the wireless cabin shown above is a reconstruction which was set up by the Marconi Marine Company in a Jubilee exhibition at the Baltic Exchange in 1950.

On the left of the operating table may be seen the two coherer-type receivers, each enclosed within its tin screening box, the fronts of which are open. To the left of each receiver can be seen the plunger-type switch which was used to disconnect the receiver during transmission periods and which was operated by a cord-and-pulley arrangement from a lever on the side of the Morse key.

In the centre of the table is the Morse inker while on the right is the bank of Leyden Jars and the 10″ induction coil which constituted the transmitter.

On the wall above the transmitter is the wooden box which enclosed the aerial tuning inductance. The letters 'EA' are of no significance and are symbolic only of the practice at the time of exhibiting the station's call sign above the operator's table.

While the future of the Marconi system was in doubt, he consistently refused to exploit the situation for his personal advantage. There were many temptations to distract a man of weaker character. The exclusive use of the Jackson system in the Royal Navy would have enabled the Treasury to outwit Marconi; their gratitude, whether expressed in the Honours List, in rapid promotion or merely in unwritten commendation, would have satisfied the conscience of the average officer that he had served his country in the strict line of duty. Jackson saw the situation with unusual clarity, and refused to take the easy and rewarding path open to him. He refused to accept any but the best equipment for the Royal Navy, and came through this critical period with his reputation enhanced in consequence. In those months he created the unique relationship which has always existed between the radio industry and the fighting services in Great Britain.

When his actions are considered in detail, an interesting pattern emerges.

As early as September 1896, he stressed the importance of testing an apparatus designed specifically for naval requirements:[13]

> '. . . it is still in the laboratory stage . . . I therefore think that little more would be gained by a trial in its present stage; but as the principle of its working has been established with such good results, I consider that a design might well be prepared and made suitable for the roughest usage.'

The specification was outlined to Marconi by letter during the same month.[16]

When such an apparatus was available, he subjected it to severe tests in adverse conditions,[16] on the 19th May 1897, and to extensive safety investigations.[18] His insistence on environmental testing established this principle firmly in the wireless branch of the Navy, as shown by the varied conditions of working tried during the 1899 Summer Manœuvres.[43]

In October 1899, Jackson was in the unique position of being able to lay down the policy for radio development in the Royal Navy. His decision, on the face of it a conservative one, was to standardize the system. In fact, his reasons for this decision were highly unconventional by the prevailing standards. His aims were to increase the efficiency of training by ensuring that operators would never be faced with unfamiliar apparatus, and to increase the standard of maintenance by reducing the variety of spare parts which a ship would need to carry. In both aims, he was remarkably successful.

By the end of the nineteenth century, Jackson had therefore established three important principles in the wireless branch of the Service – design to meet an operational requirement, environmental testing, and reduction in variety of equipment and spare parts – as the means of achieving the maximum efficiency. These three principles have ever since been accepted as governing the standards of both the radio industry and the radio branches of the fighting services.

Jackson's policy is an example of the general attitude of engineers in the early twentieth century. The outstanding figures of nineteenth century engineering are the great inventors – Bell, Edison, Bessemer, and others. These men were succeeded by a new generation with new conceptions; the new engineers were such men as

14 **The s.s. *Lake Champlain* in 1901.** The first merchant vessel to be equipped with Marconi's system was the *Kaiser Wilhelm der Grosse*, owned by Norddeutscher Lloyd, the installation being completed on 28 February 1900. In November 1900, wireless equipment was fitted to the Belgian steamer, *Princesse Clementine*, which sailed on the Dover-Ostend route, but the first *British* merchant ship to be fitted with Marconi apparatus was the ss *Lake Champlain*, the installation being completed in May 1901.

Ford, Taylor and Gilbreth, for whom invention was but one item in the industrial process. Jackson's particular contribution to the new technology was his demonstration of how to assess the user's requirements and how to meet them at the production stage.

Technology, especially naval technology, advanced rapidly in the last ten years of the nineteenth century. Marconi and Jackson were responsible for one of the most dramatic aspects of that advance.

Later work of Sir Henry Jackson

Marconi's achievements during the twentieth century are well known. Jackson, too, gained great honour, and reached the highest ranks both as a sailor and as a scientist. During the First World War, he was promoted to the rank of Admiral of the Fleet and appointed to the post of First Sea Lord. His scientific work led to his election to a Fellowship of the Royal Society in 1901. In the following year he published a classic paper in the *Proceedings* of that Society, giving the first complete description of the phenomena associated with long range radio telegraphy.[84]

He was an active member of the Royal Society and of the Institution of Electrical Engineers until, shortly before the First World War, his naval duties became so heavy as to leave no time for scientific study. In 1919, his active service in the Royal Navy came to an end, and he was appointed the first Chairman of the Radio Research Board of the Department of Scientific and Industrial Research.

There is often a tendency to criticize the appointment of a retired military leader to a high post in the Civil Service. Jackson's appointment met with no such criticism; his experience, ability and personal character were enough to ensure the universal approval of the radio industry. Few of his contemporaries, however, can have anticipated the amazing recovery of energy that he experienced in the last decade of his life. Being released from his Service obligations, he was able to devote more time to the professional Societies and Institutions, and he rarely missed a meeting at which the work of the Radio Research Board was discussed. He died at his home, on Hayling Island, on the 14th December 1929.

His life's work can be summed up in the words used to describe the purposes of the Radio Research Board under his chairmanship:[85]

> '. . . the results of scientific research undertaken on a basis of pure physics . . . may be made readily accessible to the experiments in designing apparatus . . . In this way the work of physicists interested in the subject will have the best chance of being brought into direct relation with practical advances in the art of wireless signalling; and those responsible for the development of apparatus will have at their command the scientific foundation without which their work cannot proceed satisfactorily.'

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Appendix 1

This syllabus, prepared by Marconi and Jackson in consultation and appended by the latter to his report to the Admiral Commanding 'B' Fleet, dated 10th August 1899, on the conclusion of the 1899 manœuvres, was used as a basis for the first wireless courses in HMS *Vernon* and HMS *Defiance*:

Course of 10 days' Instruction for Operators of the Wireless Telegraph with a previous knowledge of the Morse Code, proposed by Mr Marconi.

How to connect cells in series or parallel, and to understand the possibility and danger of short circuits. A knowledge of the connections of transmitting apparatus, battery, key, induction coil, and earth.

Adjustments of spark, adjustments of contact breaker, and how to remedy small defects in the insulation of coil.

A knowledge of the connections of the receiver, cells, relay, tapper, tube, jigger, chokers, shunts and earth.

How to adjust and test relay.

To mount and test a tube, how to adjust tapper, and how to adjust inker and change paper.

How to mount and insulate aerial wire, and knowledge of how to fit it to a ship, how to test insulation of aerial wire, and earth tests.

Practical signalling.

Appendix 2

List of Ships of the Royal Navy scheduled to receive Wireless Telegraphy Apparatus, 31st December 1901.

Channel Squadron

HMS Arrogant*
HMS Hannibal‡
HMS Majestic*
HMS Diadem*
HMS Jupiter‡
HMS Niobe*
HMS Furious*
HMS Magnificent*
HMS Pelorus‡
HMS Prince George‡
HMS Mars‡
HMS Repulse‡
HMS Pactolus‡

Mediterranean Squadron

HMS Andromeda*
HMS Diana‡
HMS Pyramus‡
HMS Theseus†
HMS Vulcan*†
HMS Barham‡
HMS Gladiator‡
HMS Ramilies†
HMS Tyne
HMS Victorious‡
HMS Canopus*
HMS Pioneer‡
HMS Renown*
HMS Vindictive‡
HMS Caesar‡
HMS Devastation‡
HMS Hood‡
HMS Illustrious‡
HMS Naiad‡
HMS Royal Oak‡
HMS Royal Sovereign‡
HMS Rupert‡
HMS Scout‡
HMS Formidable‡
HMS Implacable*

Reserve Squadron

HMS Camperdown‡
HMS Revenge*
HMS Galatea‡
HMS Sans Pareil*
HMS Melampus*
HMS Resolution‡
HMS Collingwood‡
HMS Benbow‡
HMS Anson‡
HMS Australia‡
HMS Severn‡

Port Guard Ships

HMS Nile‡
HMS Trafalgar‡
HMS Empress of India‡

China Squadron

HMS Albion‡
HMS Blenheim‡
HMS Eclipse‡
HMS Endymion†
HMS Arethusa†
HMS Barfleur†
HMS Cressy‡
HMS Glory*
HMS Orlando‡
HMS Argonaut
HMS Astraea‡
HMS Aurora‡
HMS Dido‡
HMS Isis‡
HMS Pique‡
HMS Talbot‡
HMS Terrible‡
HMS Goliath*

Cruiser Squadron

HMS Hyacinth*
HMS St. George*
HMS Juno*
HMS Minerva*
HMS Brilliant‡

Shore Stations

Culver Cliff *
Dover *
Portland *
Rame Head *
Roche's Point *
Scilly *
Malta *
Gibraltar *
St. Anne's Head ‡
Bere Island §
Languard §
Spurn Head §

Queensland Government

Two sets of improved Jackson pattern ‡ were reserved for the Queensland Government

East Indies

HMS Fox

Cape

HMS Gibraltar

Ships in Reserve, fitted to Receive the Apparatus

HMS Ariadne
HMS Hawke
HMS Aboukir
HMS Edgar
HMS Vengeance
HMS Blake
HMS Powerful
HMS Retribution

Torpedo Schools

HMS Vernon * (2 sets)
† (1 set)
‡ (1 set)

HMS Defiance * (1 set)
† (2 sets)
‡ (1 set)

Notes:

(i) The sets issued are identified as follows:

*Marconi sets
†Original (1899) Jackson sets
‡Improved (1901) Jackson sets
§Original Jackson sets, modified to 1901 standards.

(ii) Certain ships had not had specific sets allocated at this date.

(iii) This table is reproduced from the Annual Report of the Torpedo School for 1901, Wireless Telegraphy Appendix, Page 111.

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